Thirteenth Annual Meeting

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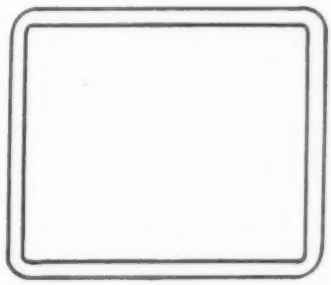
JUNE 21-25

INSTITUTE OF FOOD TECHNOLOGISTS

The Prescott Citation
See page 8
Program Preview
See page 12

FOOD TECHNOLOGY

PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS



IN THIS ISSUE

Bitterness in Navel Orange Juice

What Federal Agencies Are Doing in Poultry Dressing Sanitation

An Application of Oxidation-Reduction Potentials to Frozen Fruits Treated With Ascorbic Citric Acid Mixtures

Coliform Bacteria from Orange Concentrate and Damaged Oranges

Effects of Processing Variables on Leaching Loss, Carotene Content, and Susceptibility to Browning in Dehydrated Carrot

The Improvement of the Flavor of Dehydrated Vegetables by the Addition of Vegetable Juice Concentrates

Studies on Meat. IV. The Use of Antibiotics in Preservation of Fresh Beef

Some Observations on the pH of Pork Under Various Conditions

Quality Control—Its Significance, Implementation, and Practice

Surface Darkening of Foods in Glass Containers With Metal Caps

Recent Advances in Potato Granule Technology

Antibiotics in Food Preservation. I. The Influence of Subtilin on the Thermal Resistance of Spores of Clostridium Botulinum and the Putrefactive Anaerobe 3679

A Comparison of the Triangular and Two-Sample Taste-Test Methods

On Plank's Rational Method of Grading Food Quality

Affairs of the Institute

April, 1953 Pages 145-188 Volume 7, Number 4

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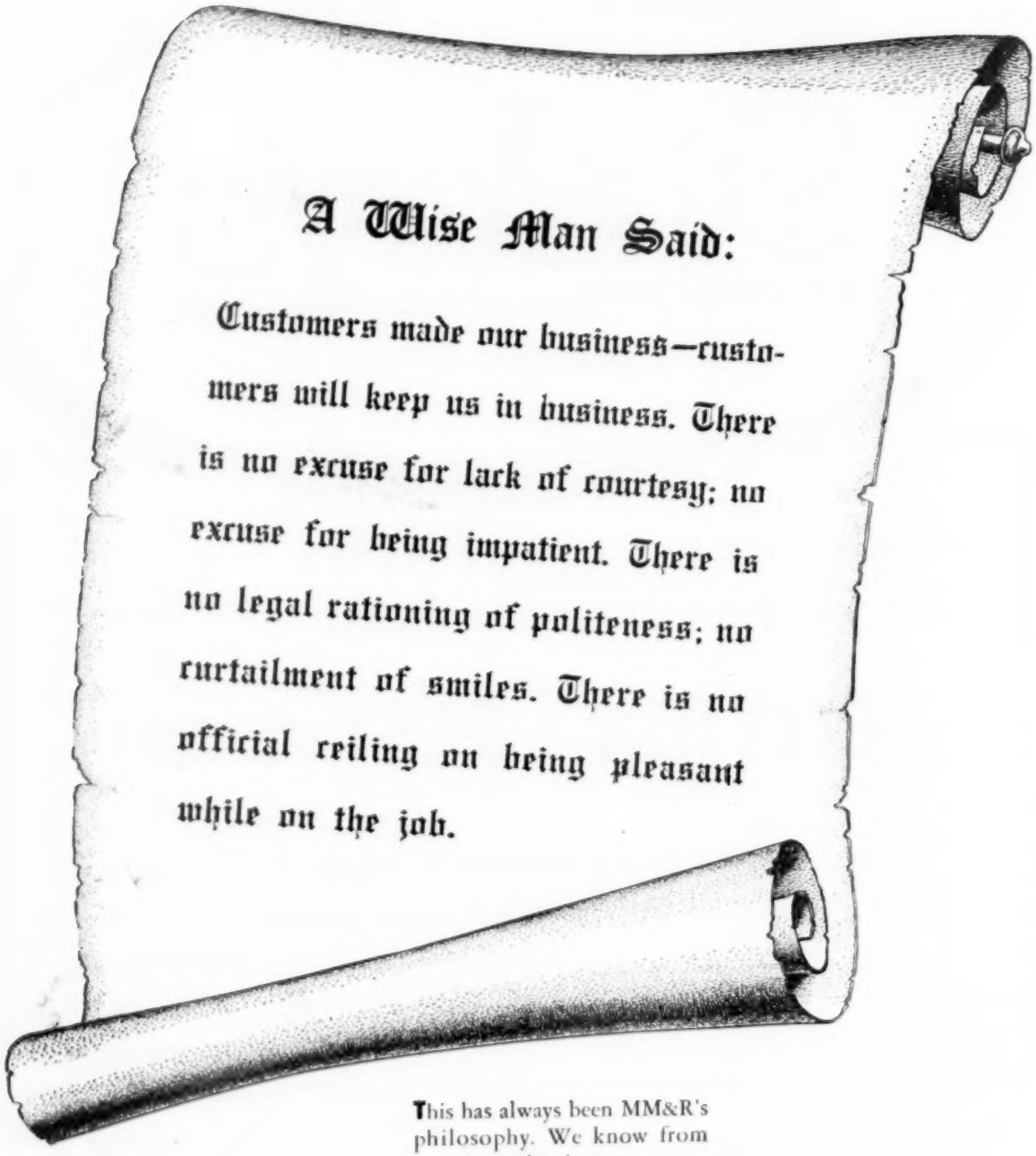
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Volume 7 **April 1953** **Number 4**

Contents

BITTERNESS IN NAVEL ORANGE JUICE. George L. Marsh 145

WHAT FEDERAL AGENCIES ARE DOING IN POULTRY DRESSING SANITATION. Harry E. Goresline . . 150

AN APPLICATION OF OXIDATION-REDUCTION POTENTIALS TO FROZEN FRUITS TREATED WITH ASCORBIC CITRIC ACID MIXTURES. Edward Ross, D. S. Bartlett, and Margaret M. Hard 153

COLIFORM BACTERIA FROM ORANGE CONCENTRATE AND DAMAGED ORANGES. Roger Patrick . . . 157

EFFECTS OF PROCESSING VARIABLES ON LEACHING LOSS, CAROTENE CONTENT, AND SUSCEPTIBILITY TO BROWNING IN DEHYDRATED CARROT. Carl E. Hendel, R. R. Legault, and William F. Talburt . 160

THE IMPROVEMENT OF THE FLAVOR OF DEHYDRATED VEGETABLES BY THE ADDITION OF VEGETABLE JUICE CONCENTRATES. Frank A. Lee, J. C. Hening, and C. S. Pederson 162

STUDIES ON MEAT. IV. THE USE OF ANTIBIOTICS IN PRESERVATION OF FRESH BEEF. H. S. Goldberg, H. H. Weiser, and F. E. Deatherage 165

SOME OBSERVATIONS ON THE pH OF PORK UNDER VARIOUS CONDITIONS. John F. McCarthy and David L. Mackintosh 167

QUALITY CONTROL—ITS SIGNIFICANCE, IMPLEMENTATION AND PRACTICE. Milton E. Parker . . . 171

SURFACE DARKENING OF FOODS IN GLASS CONTAINERS WITH METAL CAPS. Edward F. Kohman (Consultant) and Ronald L. Cole 174

RECENT ADVANCES IN POTATO GRANULE TECHNOLOGY. R. L. Olson, W. O. Harrington, G. H. Neel, M. W. Cole, and W. R. Mullins 177

ANTIBIOTICS IN FOOD PRESERVATION. I. THE INFLUENCE OF SUBTILIN ON THE THERMAL RESISTANCE OF SPORES OF CLOSTRIDIUM BOTULINUM AND THE PUTREFACTIVE ANAEROBE 3679. F. R. LeBlanc, K. A. Devlin, and C. R. Stumbo 181

A COMPARISON OF THE TRIANGULAR AND TWO-SAMPLE TASTE-TEST METHODS. Albert J. Byer and Dorothy Abrams 185

ON PLANK'S RATIONAL METHOD OF GRADING FOOD QUALITY. A. S. C. Ehrenberg 188

AFFAIRS OF THE INSTITUTE

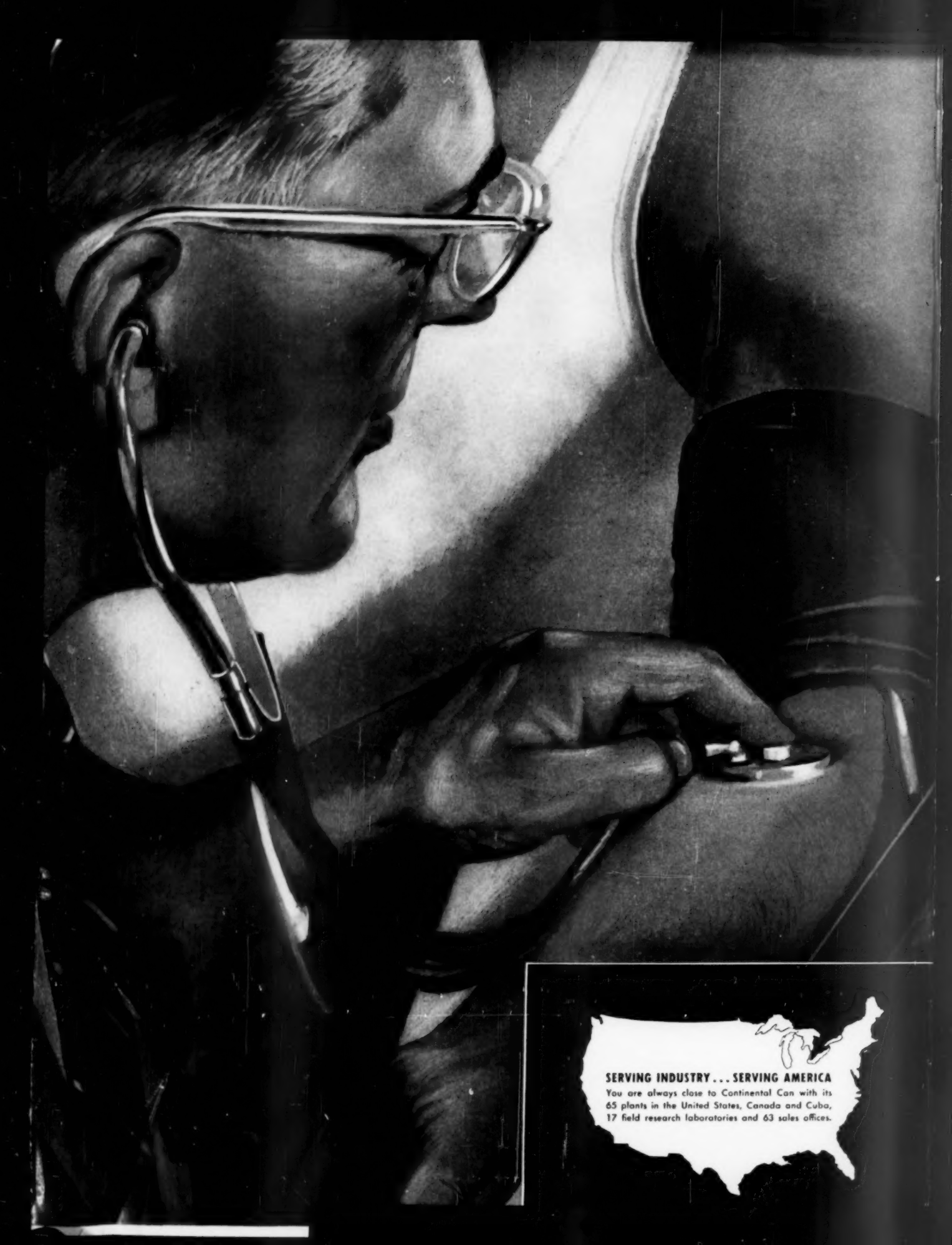
FAMOUS FOOD TECHNOLOGIST TO BE HONORED AT NATIONAL MEETING OF FOOD TECHNOLOGISTS IN BOSTON 8

TENTATIVE PROGRAM OF THE 1953 IFT ANNUAL MEETING 12

REGIONAL SECTION NEWS 14

BOOKS 20

SELECTED ABSTRACTS 22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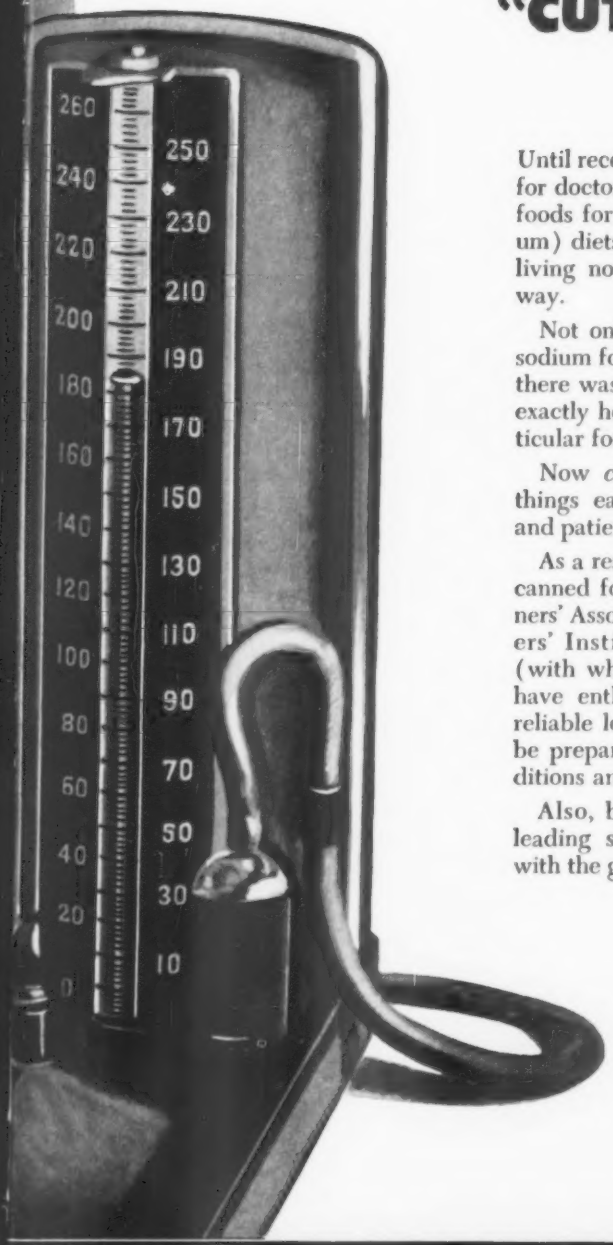

Until recently it was extremely hard for doctors to prescribe and control foods for people on low-salt (sodium) diets—particularly for patients living normal lives in every other way.

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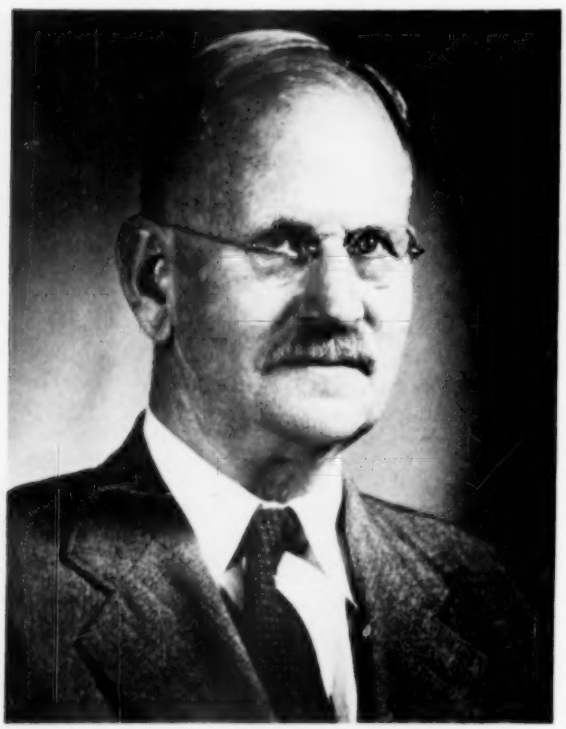
Tentative Program of the 1953 IFT Annual Meeting
Regional Section News
Personnel
Books
Selected Abstracts
Food World News
Future Meetings

Famous Food Technologist to Be Honored at National Meeting in Boston

"First among his fellow food scientists" is a phrase that would be heartily endorsed by those who know the truly great work done over the years by the scholar, scientist, and international authority on food technology —Dr. Samuel Cate Prescott, Massachusetts Institute of



SAMUEL CATE PRESCOTT . . . NAMED FOR HONOR CITATION

Technology. To honor this famous pioneer in food research the Institute of Food Technologists will hold a general assembly at their annual meeting in Boston, June 21-25, in order to confer the Institute's first Annual Citation on Dr. Prescott for his scientific acumen and intergrity and for his stalwart service in advancing food science. The citation is being given in recognition of Dr. Prescott's contributions toward founding and developing the Institute and, one might equally well say, the profession of food technology.

The canners of this country, according to Dr. A. W. Betting, author of a leading book on canning, "owe more to Prescott and Underwood for placing their industry upon a scientific basis than to any other investigators. Their work . . . dealing with the fundamental principles of bacteriology and their application to factory operations . . . was epoch-making in changing an industry based upon individual experience to one under scientific control." The economic results of Dr. Prescott's work and that of his colleague are perhaps imponderable, but it is safe to say that it gave an immense impetus to increasing the American standard of living. The volume production of safe, palatable processed foods has been one of the factors which has made possible the industrialization and the greatness of America.

Dr. Prescott, distinguished industrial biologist and emeritus professor of biology, was for many years dean of the School of Science and head of the Department of Biology and Public Health at the Massachusetts Institute of Technology. A nationally-known scientist and educator, Dr. Prescott has made outstanding contributions in the fields of bacteriology, food technology, and public health.

Under his administration at M. I. T., health education was developed as a special subject of instruction, the course in public health engineering was introduced, and programs in biological engineering and food technology were initiated. Dr. Prescott's position as a leader in the fields of practical and applied biology is also based on his work in establishing at M. I. T. the nation's first industrial biology course, his contribution to the application of enzymes to industry, his research in industrial hygiene, and his organization of the Boston Bio-Chemical Laboratory.

An important phase of Dr. Prescott's work has been his study of bacteriology as applied to food production and preservation. His research in bacteriological control in the canning industry led to the discovery of methods of sterilization, dehydration, and quick freezing of foods.

Born in South Hampton, New Hampshire, in 1872, Dr. Prescott studied at Sanborn Seminary (Kingston, N. H.) before entering M. I. T., where he received the degree of bachelor of science in 1894. He then held a position as chemist for the Worcester Sewage Purification Works and, the following year, joined the Institute staff as an assistant in biology. Dr. Prescott was named instructor in 1896, and in that year he and the late William Lyman Underwood published the first of a distinguished series of papers on the fundamental relationship of time and temperature in the canning industry. Their application of the fundamental principles of bacteriology to factory operations resulted in practical methods of food preservation and sterilization. This work, which was to cover a period of about ten years, laid for the first time a sound basis for scientific control of the canning industry.

In 1900 Dr. Prescott devoted several months to post-graduate study in Berlin and Copenhagen. His appointment as assistant professor of industrial biology at M. I. T. came in 1903, associate professor in 1909, associate professor of industrial microbiology in 1912, and full professor in 1914. During a leave of absence from 1918-19 he served in Washington as chief of the division of dehydration in the Bureau of Chemistry. There he

(Continued on page 10)

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Famous Food Technologist to Be Honored at National Meeting in Boston

(Continued from page 8)

devoted himself to an exhaustive study of the application of low temperature for food preservation, an investigation which led into the field of quick freezing. In 1919 Dr. Prescott was named professor of industrial biology at M. I. T., a post which he held until his retirement in 1942.

His administrative work at the Institute included an appointment as acting—and then permanent—head of the Department of Biology and Public Health in 1921 and 1922 respectively. Ten years later he was appointed the first dean of the School of Science. After 1942, when he retired from both positions, Dr. Prescott served for two years as honorary lecturer in the Department. He has continued at M. I. T. as emeritus professor of industrial biology.

Dr. Prescott's varied experiences in the field of applied bacteriology have included consultation activities with food industries; and investigations of water and milk supplies, food manufacture, technical aspects of the fishery industry, and court cases relating to the sanitary quality of foods.

From 1902-09 Dr. Prescott was instructor in bacteriology at Simmons College in Boston; from 1904-21 he was director of the Boston Bio-Chemical Laboratory, where he trained an able staff of research scientists who aided in the solution of innumerable technical problems of food production and preservation; and from 1910-15 he served on the staff of the Sanitary Research Laboratory and Sewage Experimentation Station.

Several years before World War I, Dr. Prescott was sent to Central America by the United Fruit Company to study a disease which was then spreading through the banana plantations of Costa Rica. There he made the first serum inoculation tests performed on plants. In 1914 he returned to the tropics to establish a United Fruit Company research laboratory in Port Limon for study of the disease in five countries. This work included the most extensive soil examinations ever made by a private organization. Dr. Prescott's research confirmed the existence of the "Panama disease" in bananas, worked out the life history of its cause, and proved the disease preventable by proper plant nutrition. His three years as director of the laboratory also included important studies in food preservation.

During World War I Dr. Prescott, serving as a major in the Sanitary Corps of the United States Army, had charge of inspection of foods, research on dehydration, and the problems of storage at the great army training camps. His work included the development and specifications for dehydrated foods sent to troops abroad. As an outgrowth of these investigations he was, in 1918, appointed director of the division of dehydration, Bureau of Chemistry (Department of Agriculture) in Washington. One year later he received his discharge from active service. In 1920 he was promoted to lieutenant colonel in the Officers' Reserve, Sanitary Corps; in 1925, colonel.

A three-year study of the chemistry and preparation of coffee, which he began in 1920 at the request of the Joint Coffee Research Committee, gained international notice. Since World War I Dr. Prescott has continuously conducted researches in the technical aspects of such branches of the food industry as food preservation, domestic refrigeration, and formation of commercial solvents by fermentation. Through his work in this field a program in food technology was established at M. I. T., first as a divison of the Biology Department (1944) and later as a separate department.

During World War II, after a year's volunteered service to the Office of the Quartermaster Corps, U. S. Army, Dr. Prescott was appointed Special Consultant to the Secretary of War for the purpose of aiding in inspection and establishment of dehydration plants for the Army. This part-time service involved consultations, visits to plants throughout the country, and assistance in the development of improved methods of dehydration of vegetables and fruits. In 1944 he also prepared a detailed report on U. S. Army troop feeding programs from 1775-1940 for the Office of Scientific Research and Development of the National Research Council.

After his retirement from the Institute's administration Dr. Prescott became consultant both to the dehydration committee of the U. S. Department of Agriculture and to the research laboratories of the National Canning Association.

Dr. Prescott received honorary degrees of doctor of science from Bates College (1923) and from Lehigh University (1947), and in 1943 he was awarded the emblem for civilian service by the War Department. Also in 1943 the Chicago section of the Institute of Food Technologists presented Dr. Prescott its Nicholas Appert Medal, in recognition of pre-eminence in the field of food technology and contributions to the progressive development of food manufacture and processing. He was chosen by the Institute of Food Technologists as 1951 recipient of the Stephen M. Babcock award for distinguished contributions in the field of food technology resulting in improved public health.

In 1937 Dr. Prescott sponsored the first international Food Technology Conference, and in 1939 the Institute of Food Technologists was established with Dr. Prescott as its first president.

Dr. Prescott is a fellow of the American Association for the Advancement of Science and the American Academy of Arts and Sciences; a member of the American Chemical Society; and a member and past president of the M. I. T. Alumni Association, the Institute of Food Technologists, the Society of American Bacteriologists, and the American Public Health Association. He is also a member of Sigma Xi, Harvard Travellers, and Brookline Thursday clubs.

Dr. Prescott has also served as chairman of the M. I. T. faculty, member of the Sanborn Seminary board of trustees, trustee of the Tropical Plant Research Foundation, and chairman of the board of directors of the Refrigeration Research Foundation, Inc.

Translations by Dr. Prescott include Effront's "Enzymes and Their Application," "Biochemical Catalysts in Life and Industry," and "Proteolytic Enzymes." He

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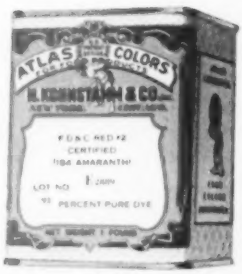

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(Continued from page 10)

is also co-author of a devision of Sedgwick's "Principles of Sanitary Science and Public Health," and co-author of "Elements of Water Bacteriology with Special Reference to Sanitary Water Analysis," "Science and Experiment as Applied to Canning," "Food Technology," and "Industrial Microbiology." Dr. Prescott has been associate editor of "Food Research" and a contributor to the "American Cyclopaedia of Agriculture," as well as to technical journals on bacteriology, food technology, and industrial biology.

In 1910 Dr. Prescott was married to Miss Alice D. Chase of Derry, New Hampshire. Their children are Robert Sedgwick, Samuel Chase, and Eleanor (Mrs Richard V. Clemence); and their home is in Cambridge, Massachusetts.

R. J. G. AND M. S. P.

Tentative Program of the 1953 I. F. T. Annual Meeting

Advance information on the 1953 Annual Meeting of the IFT to be held in Boston, Massachusetts in June is now available for release.

The headquarters will be the Hotel Statler. The Executive Council will meet on Saturday, June 20, at 9:30 a.m. and continue in session until 5:00 p.m. The Editorial Board will also meet on Saturday, June 20.

On Sunday, June 21, the National Council will meet at 10:00 a.m., continuing in session until the completion of business.

Mixer. On Sunday evening, a Mixer will be held in the Ballroom, the lady guests being as welcome as all members. Admission will be complimentary.

While arrangements can be made for Committee Meetings on Monday, Tuesday, or Wednesday, it is recommended that wherever possible Committee Chairmen call their sessions for Saturday or Sunday in order to relieve the time schedule.

Monday, June 22

The General Session on Monday morning, June 22, starting at 10 a.m. will be addressed by our National President and by two guest speakers.

Noted speaker to address general session. Dr. Karl T. Compton, who needs no introduction to our group, has already accepted our invitation to be one of the speakers. His topic will be announced later.

Babcock and Food Engineering Awards. At a luncheon on Monday noon, the Babcock and Food Engineering Awards will be presented in the Ballroom Assembly.

Geriatric feeding to be featured. On Monday afternoon at a general session in the Ballroom, an interesting program looking into the future of the food industry in this country, with especial emphasis on providing proper foods for the elderly portion of our population which is ever increasing will be presented under the direction of Dr. Charles Glenn King of the Nutrition Foundation and Dr. R. C. Sherwood. In this session, speakers of national reputation will be presenting papers.

Also on Monday afternoon, there will be a session for the presentation of contributed research papers.

Boston Pops concert. On Monday evening the entire convention will attend a concert of the Boston Pops Orchestra, and arrangements have been made to take over the entire ground floor. Refreshments will be complimentary and guests are also invited.

Tuesday, June 23

On Tuesday morning, June 23, there will be a session devoted to problems with fermented food products (pickles, kraut, etc.) under the chairmanship of Dr. Fred Fabian. Also on Tuesday morning, there will be a general session on chemicals in foods under the chairmanship of Dr. Charles Frey.

On Tuesday, at both morning and afternoon sessions, there will be a program devoted to the fish industry under the joint chairmanship of Dr. Hugh L. A. Tarr and Dr. W. H. Hampton.

On Tuesday afternoon, there will also be a session for contributed research papers.

On Tuesday evening, the annual Appert Award Banquet will take place at which guests are invited.

Wednesday, June 24

Appert medalist address to feature canning and processing session. On Wednesday, June 24, at both morning and afternoon sessions, there will be a program devoted to canning and processing under the joint chairmanship of Dr. E. J. Cameron and Dr. C. Olin Ball. Included in this program will be the address of the Appert medalist.

On Wednesday morning there will be a session devoted to packaging papers under chairmanship of Dr. L. W. Elder.

On Wednesday, both morning and afternoon, there will be a session devoted to fruits and vegetables under the chairmanship of Dr. Emil Mrak and in cooperation with the Quartermaster Food and Container Institute for the Armed Forces.

Clambake. On Wednesday evening there will be a Clambake held at the Field House on the M.I.T. Campus at which members and guests are invited.

Volunteered Papers Will Still Be Considered

Due to the limitation of meeting rooms at the hotel, program time is at a premium. Already quite a number of contributed research papers have been submitted, and any members who would like to present a paper are urged to send in the title and a brief abstract, together with authorship, to the Program Chairman, Dr. J. A. Dunn, Atlantic Gelatin Division, General Foods, Woburn, Massachusettes. It is recommended that, wherever possible, research papers be presented in condensed form, omitting details of procedure and stressing an outline of the problem, a discussion of the experimental results, and the conclusions.

The final program for the meeting will appear in the May issue of FOOD TECHNOLOGY.

(Continued on page 14)

Keep Product Quality Up—Production Costs Down

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FMC specialized tomato equipment helps build profits for processors three important ways: (1) it *cuts costs* of operation and maintenance throughout the line by using continuous automatic methods; (2) it's *flexible*—types and sizes available to meet varying plant and operational requirements; and (3) it assures a consistently *high-quality* pack of tomatoes, tomato juice and other tomato products.

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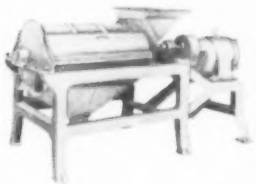
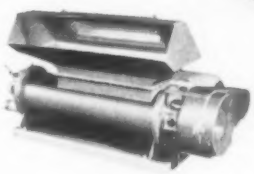


FMC PULPERS and FINISHERS
Heavy duty stainless steel paddles and screens. Capacities: Pulpers, 5 to 20 tons per hr. Finishers 20 to 100 GPM.



FMC TOMATO CHOPPER
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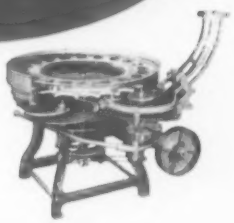

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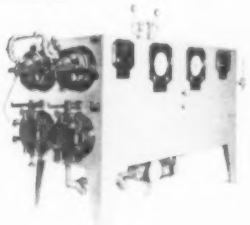

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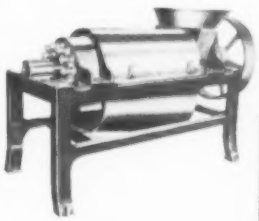

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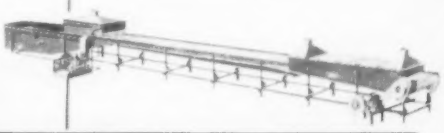

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Tentative Program of the 1953 IFT Annual Meeting

(Continued from page 12)

CHAIRMEN AND COMMITTEES IN CHARGE OF ARRANGEMENTS

Thirteenth Annual Meeting
Institute of Food Technologists
JUNE 22-26, 1953

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General Chairman: LOREN B. SJÖSTRÖM
Assistant to General Chairman: JEAN F. CAUL

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I. E. Malkin, Richard Parsons

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REGISTRATION
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Edward E. Anderson, Julius Brody, Sidney L. Feener, Ruth Stevens Perry, Leonard S. Stoloff, Robert L. Swaine

Regional Section News

OHIO VALLEY SECTION

A joint meeting of the Ohio Valley and Indiana Sections of the Institute of Food Technologists was held in Dayton, Ohio, on March 7, 1953.

The program began with a plant trip to the Monsanto's Food Laboratories in the morning. This proved to be most enjoyable and instructive. In the afternoon, after registering at the lobby of Frigidaire's Moriane Auditorium, those in attendance listened to the following papers:

"Chemical in Food" (Mr. Theodore Schild of the Monsanto Chemical Company, Dayton, Ohio); "Cooking Starch Jellies Continuously" (Mr. John Bolanowski of the Girdler Corporation, Louisville, Kentucky); "Food Plant Sanitation" (Dr. Lee Truman of the Indianapolis Pest Control Company); "Antioxidants in Foods" (Mr. Al Fonyo of Wm. Stange Company); "Horticultural Research in 1952" (Dr. H. O. Brown of Ohio State University, Columbus, Ohio).

In the evening after a banquet at the Engineers' Club, Mr. F. C. Lyons, Director of Public Relations for the Dayton Divisions of General Motors, addressed the group, choosing as his topic "Three Peas In a Pod."

CHICAGO SECTION

At the February 9, 1953 meeting of the Chicago Section, Albert I. Kegan spoke on the "Bearing of the 1953 Patent Code on Food Technology."

Mr. Kegan has taught patent law, chemistry and chemical engineering, and at the present divides his time between his duties on the faculty at the Northwestern University School of Law and as a member of the law firm, Kegan & Pitnis. The firm specializes in the legal aspects of food technology.

On January 1, 1953, a new Patent Code was established, the provisions of which were explained by the speaker. The new code combines the elements of previous rulings established through precedent and court rulings. It is the first such major revision since 1870. Methods used to judge when an invention is patentable, employer-employee rights, package design copyrights, correcting errors in patent applications, and latitude allowed in preparing applications, were among the items discussed.

Committee chairmen for the coming year are:

Program—S. F. Brockington, The Quaker Oats Company.

Finance—E. W. Hopkins, Armour & Company.

Publications—B. J. McKernan, Continental Can Company.

Membership—W. R. Schack, Swift and Company.

House—W. J. Imig, Jr., Consolidated Food Processors.

Hospitality—Alice Mary Amis, The Quaker Oats Company.

Auditing—L. Newsome, Continental Can Company.

Public Relations—E. W. Nordlinger, *Food Processing* Magazine.

(Continued on page 16)

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Regional Section News

(Continued from page 14)

NEW YORK SECTION

New Technical Knowledge Revealed by Young Research Workers at January Meeting

Interesting new practical technical information was presented by five young food laboratory technologists at the unusual January symposium of the New York Section of IFT.

Recent developments at The Best Foods Laboratories in the stabilization of edible fats were reviewed by Carl Brown. Mono-isopropyl and mono-stearyl citrates, since they are much more soluble and easier to use, are preferred to citric acid as metal-deactivators in edible oils and fats, where deterioration may occur as a result of unavoidable iron and copper contamination.

These esters not only extend the keeping-time, but also improve the overall flavor performance of oils. A modified A.O.M. test, utilizing iron tubes in place of the customary glass tubes in a comparison of commercial antioxidants, demonstrates the superiority of the citric acid esters in protecting oils against continual metal pick-up.

A comparative study of fresh orange juice and frozen concentrates, carried out on a monthly basis over a two year period, was discussed by Mathlida D. Zinn, Good Housekeeping Bureau. Samples were purchased in five representative neighborhood stores. The two-year averages show (1) comparable vitamin C levels for the fresh and frozen juices, (2) more uniform sugar-acid ratios for the frozen juice, (3) lower and more uniform peel oil levels for the frozen juice (peel oil in fresh juice varies widely with the type of reamer used) and, (4) for the New York area, consistently lower cost per 100 cc. of juice for the frozen concentrates. Taste panels generally preferred the flavor of the fresh juices. How to achieve maximum production from a gelatin evaporator-dryer installation was described in a paper by Franklin Dramer and Louis Garono, General Foods Central Research Labs. First, steam pressure on the evaporator was increased, and baffles were installed in the dryer tunnel to prevent air bypass.

Next, the water-removal loads on evaporator and dryer were balanced for maximum combined output. Curves were plotted for capacity of evaporator effluent—under both summer and winter operating conditions. The points where evaporator and dryer curves crossed gave the proper effluent concentration for maximum throughput of the system.

A new technique, using the Millipore Filter, to concentrate and enumerate microorganisms in large volumes of liquids was described by Carroll P. Burke, National Dairy Research Laboratories. The original purpose of this filter was to determine low numbers of coliform organisms in water supplies.

Preliminary investigations have shown that in artificially infected water, higher counts were detected than by the standard plate count. And these higher counts were accompanied by sterile effluents.

These results prompted work to determine if the filter might be used to evaluate the sanitation of pipe lines and other equipment. Laboratory tests showed this to be applicable. Plant runs using this technique were made and the results were favorable.

The filter can also be used in enumerating psychrophilic bacteria in milk, checking air contamination of large areas, and producing a sterile air supply.

And this filter is further visualized for the examination of concentrated food products for which existing sterility tests are inadequate.

A rapid and accurate method for the analysis of the sulfhydryl groups in milk, developed in The Borden Co. biochemical research laboratories, was explained in a paper by Guntef Zweig and Richard J. Block.

Located in the whey protein fraction, the sulphydryl groups are determined by a method based on the titration of mercapatans. The method may be adapted to the quality control of milk; e.g., determining the extent of heat treatment to which a milk sample has been subjected. The apparatus consists of a rotating platinum electrode, a calomel electrode, a galvanometer and an automatic buret.

"Good Patent Management Pays" was the subject of February meeting addess. It takes good patent management to assure the economic success of invention in the food processing industry. This was demonstrated through patent case histories at the February 18 meeting of the New York Section of the Institute of Food Technologists.

The importance of thorough patent search and subsequent fool-proof drafting of patent claims was stressed by the speaker, Alf K. Berle, Boston lawyer and research consultant. An instance was cited in which the inventor advisedly spent $30,000 for patent searches and patent preparation to protect a development worth millions of dollars.

The food technologists were cautioned against making patent claims too broad and risking invalidation of their patent. "Claim everything to which you are entitled, but no more," he said. A patent must be wisely managed so as not to create the incentive or establish the basis for successful attacks against it in the courts, Mr. Berle pointed out. At the same time, a patent must be defended in the courts to clearly establish its validity and make it pay off economically.

AUSTRALIA NORTHERN SECTION

The division of the Australian Section into two separate sections became official at the beginning of the year. The name of Section 19 becomes Australian Northern Section, and the Australia Southern Section becomes No. 23. Cooperation between the two groups will be very close, and the idea of having an Annual Australia-wide Convention will be retained. The Southern Section will be hosts at this year's Convention, which will be held in May at Healesville, near Melbourne.

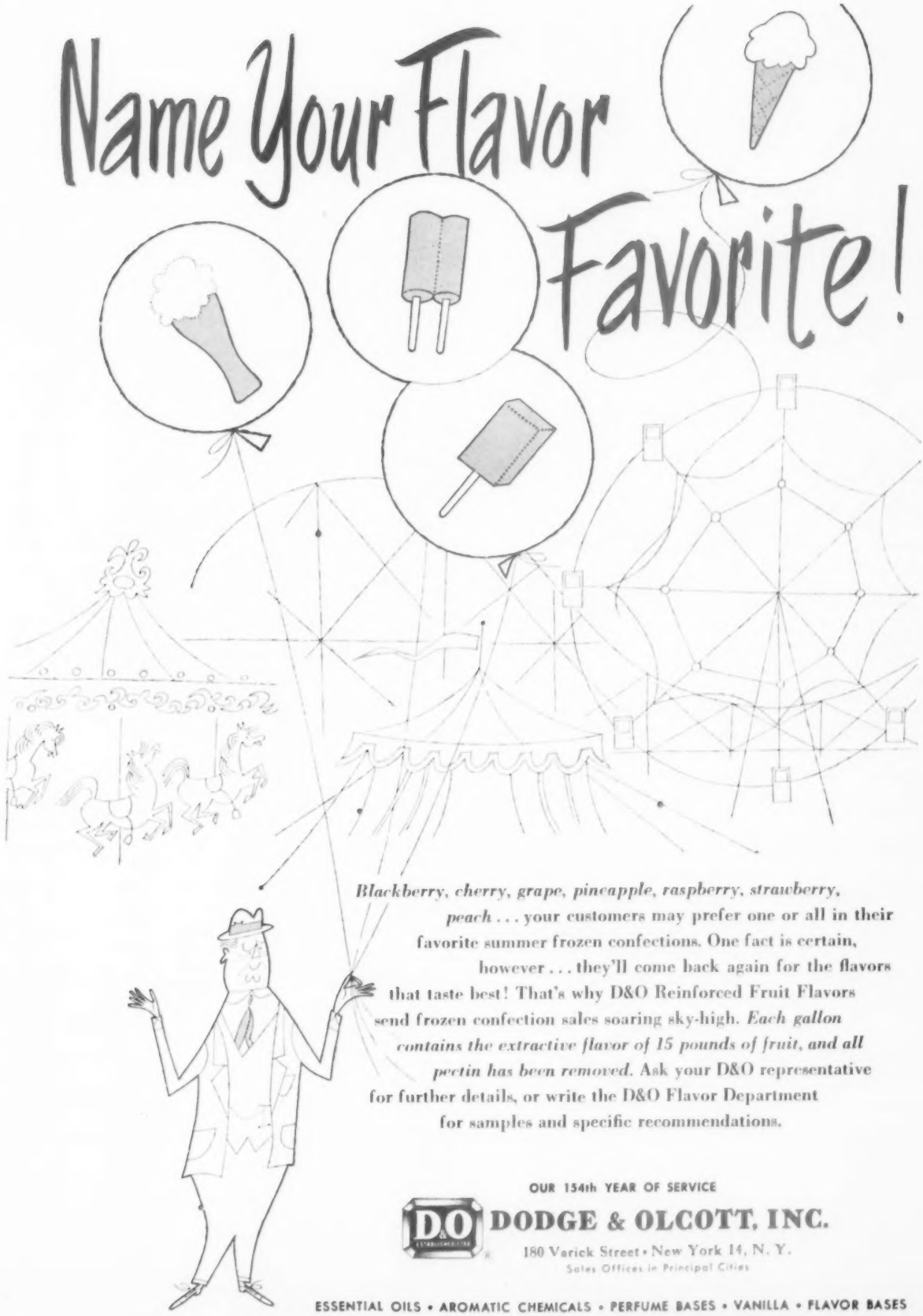
The December meeting was held at Cahill's Restaurant, Sydney, and was in the nature of a Christmas party. There were numerous guests present, and entertainment included items by Jack Kefford's Food Preservation Glee Singers, and dancing to the tunes of Bill Syke's string ensemble. Liquid refreshment was provided by our two brewers, Hugh Govers and John Roche.

A more serious note was struck at the next meeting, held on February 19th at Sydney University. Following a buffet dinner, there was a symposium on "Chemicals in Food." Mr. M. Martin of Cottee's Passiona Ltd. discussed the subject from the angle of the food manufacturer, pointing out the achievements which have resulted from the application of chemicals to foodstuffs. The attitude of the State Department of Health was presented by Mr. W. Ogg, who stressed the necessity of maintaining a wholesome supply of food, and outlined the criteria used by his Department in considering applications for the addition of chemicals to food products. The Department of Pharmacology at Sydney University supplied the third speaker, Professor Thorpes, who discussed methods of assessing the toxicity of chemical compounds, paying particular attention to the shortcomings of feeding tests on experimental animals, and advocating more fundamental work on the metabolism of food chemicals in the human body.

Messrs. L. J. Lynch and R. S. Mitchell, both of this Section, shall be resident for a short time at the N. Y. State Agricultural Experiment Station, Geneva, N. Y., where they will test the application of their recently developed methods for maturity prediction in peas under American conditions. Mr. Lynch will act as proxy-Councilor for the Australia Northern Section at the forthcoming Institute meetings.

(Continued on page 18)

Name Your Flavor Favorite!



Blackberry, cherry, grape, pineapple, raspberry, strawberry, peach . . . your customers may prefer one or all in their favorite summer frozen confections. One fact is certain, however . . . they'll come back again for the flavors that taste best! That's why D&O Reinforced Fruit Flavors send frozen confection sales soaring sky-high. *Each gallon contains the extractive flavor of 15 pounds of fruit, and all pectin has been removed.* Ask your D&O representative for further details, or write the D&O Flavor Department for samples and specific recommendations.

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Regional Section News

(Continued from page 6)

WESTERN NEW YORK SECTION

The Buffalo Area of this Section held a dinner meeting on March 2, 1953, in the Ivy Room of the New York State Institute of Applied Arts and Sciences, 1685 Elmwood Ave., Buffalo, New York. Guest speaker for the occasion was Dr. G. J. Hucker N. Y. State Agriculture Experiment Station, Geneva, N. Y., who discussed "The Bacteriology of Frozen Foods." The bacteriology of frozen foods is of fundamental importance, not only to the frozen food processors, but to all processors of foods. Dr. Hucker's long and intensive association with his subject made this an interesting and informative discussion.

NORTHERN CALIFORNIA SECTION

The Section held its February meeting on the 19th at the Merchandise Mart, Market Street, San Francisco. This meeting was devoted to a panel discussion and question-answer period on the topic: "How Can the Food Technologists Help Solve Mass Feeding Problems." Panel members were William Barlow, Asst. Bus. Mgr., Manning Inc.; Mrs. Hilda Watson, Chairman, Hotel and Restaurant Division, City College of San Francisco; Clifford J. Shea, Executive Asst. Mgr., Sir Francis Drake Hotel, and at the time of writing it was expected that Richard Flambert, food science specialist, would also participate.

NORTHEAST SECTION

The Section met on March 5th, at the Hotel Brunswick, Boston, Mass., to hear John I. Thompson, Consulting Engineer, Washington, D. C., discuss "Factory Layout From the Point of View of the Food Technologist."

Mr. Thompson has had many years' experience, working in the food and pharmaceutical fields, in the design and development of equipment and plant layout. Some years ago, he was assistant Chief Engineer for Campbell Soup Company; he resigned his position to work as a consultant to the United States Navy during World War II, and since then has been active in his own consulting business, except for a while when he acted as an official in the Department of Agriculture.

OREGON SECTION

On February 11th the Section held a meeting in conjunction with the Oregon State College annual short course. A partial list of speakers to take part in the Oregon State College short course included: Russ Walton, National Association of Manufacturers; C. R. Havighorst, Food Engineering Magazine; Curtiss M. Everts, Jr., State Sanitary Authority of Oregon, and Franklin H. Graf, A. C. Nielsen Company, Marketing Research.

The 32nd Annual Food Processors' School, held February 9-14 by the Food Technology Department, Oregon State College, is a feature of the Oregon State College short course.

AMES SECTION

The Ames Section held its January meeting on Friday, the 30th at Iowa State College. The talks given in the afternoon and evening were all devoted to the important topic "Packaging of Foods." The speakers taking part and titles of their talks were:

"How Research Benefits the Food Industry." Dr. B. S. Clark, Scientific Director, Research and Technical Dept., American Can Company, Maywood, Illinois.

"Some Aspects of Cereal Packaging." Mr. C. E. Felt, Leader, Packaging Section, Physics Research Department, General Mills, Inc., Minneapolis, Minnesota.

"CRYOVAC Packaging." Mr. R. A. Miller, Midwest Sales Manager, Dewey and Almy Chemical Company.

"Some Technological Problems in Merchandizing Self-Service Meats." Dr. John C. Ayres, Department of Bacteriology, Iowa State College, Ames, Iowa.

The dinner speaker was Mr. C. A. McClellan, Sales Representative, Kalamazoo Vegetable Parchment Company, Des Moines, Iowa, who talked on "Parchment, the Miracle Material."

At the business meeting, Dr. B. S. Clark, Scientific Director, American Can Company, and National IFT Chairman-elect spoke to the members.

The next meeting is scheduled for Friday, April 24, 1953 at Iowa State College. John Meader of Continental Can Company, the program chairman, has an interesting program planned on "Drying and Condensing of Foods."

PERSONNEL

Howard O. Triebold was appointed head of the department of Agricultural and Biological Chemistry at the Pennsylvania State College on February 1st. He has been associated with the department since December 1926 and has served as acting head since the retirement of R. Adams Dutcher in July 1951.

MADE YOUR ROOM RESERVATION FOR THE BOSTON MEETINGS YET?

One of the happiest ways of enjoying your forthcoming visit to Boston for the annual IFT Convention is to *know* that you are all set as to where you will sleep. Even food technologists, who, from all indications are restrained professional men at home, want to be able to get away from it all, without being away from it all. Accordingly, within the next month, a letter will be sent to all IFT members asking for hotel reservations. And to make it easy, a return self-addressed stamped reservation card will be enclosed. All members are urged to take prompt action, as there are only a limited number of rooms (some 500-odd) which are available at the headquarters hotel—the Statler.

You will note that all reservation cards are addressed directly to the Statler Hotel, and crass commercialism says that rooms will be allocated on a first-come, first-served basis. When the allocated rooms at the Statler are filled, subsequent reservations will be turned over to the Chamber of Commerce Convention Bureau and assignments will be made to some other of the first-class hotels which are located within a few blocks of the Statler. The committee wishes that it could get all registrants into the Statler. This notice is to warn you that if you want to enjoy the luxury of a Hotel Statler room, you are requested to get your reservations in promptly.

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Beverages	Frozen Fresh Fruit	Pumpkin Pie Filling
Cake Icings	Frozen Fruit Juices	Ripple Ice Cream Syrup
Canned Fruit	Fruit Fillings (Pie)	Sauces (Prepared)
Cheese Spreads	Fruit Juices	Sherbet Stabilizers
Chocolate Milk	Fruit Pie Fillings	Soups
Chocolate Syrups	(canned, ready-to-serve)	Syrups
Confectionery	Gas Whipped Cream	Water Gel Desserts

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Books

STATISTICAL METHODS FOR CHEMICAL EXPERIMENTATION (210 pages), by W. L. Gore, Interscience Publishers, Inc., N. Y., Interscience Publishers Ltd., London, 1952.

As the title indicates, this book was written in an effort to provide a manual of statistical methods specifically for the use of the chemist. It is divided into seven chapters:

1. Introduction
2. Statistical Concepts
3. The Reliability of Estimates
4. Analysis of Variance
5. Design of Experiments
6. Correlation and Regression
7. Attribute Statistics,

and includes an Appendix of Tables, an Appendix of Formulas, a Glossary and a Bibliography.

The author has employed the introduction to lay a brief but broad background for the use of the statistical method in the design of experiments, the reduction of experimental data and the calculation of probabilities for hypotheses in situations likely to be met with by a chemist.

A consideration of the attributes of the normal distribution curve is used to introduce statistical concepts such as the average, the standard deviation, confidence limits, distribution of the standard deviation, and other statistical estimators.

The concept of analysis of variance is introduced through use of an example in which specific directions for computation are given, indicating in each case the type of estimate which may be obtained. The author points out the need for appropriate experimental designs for research if the analysis of variance or other techniques are to be used efficiently.

"Conventionally controlled" experiments in which one factor at a time is varied are compared with experimental designs in which several factors may be varied simultaneously. The fallacies arising from controlled experimentation in which interactions or preferential responses exist are described. The factorial design is described as a means of testing at one time several levels of several factors. An example is given. This design is also used to introduce the idea of the estimation of experimental errors in research. The effect of replication on the precision of results is discussed in a fashion which should be especially helpful to chemists. The effective use of confounding in simplifying experimental designs is discussed.

The author's statement that the 2×2 latin square is the most useful latin square in chemical experimentation is somewhat surprising. Actually, the example given is more aptly described as a $\frac{1}{2}$ replicate of a 2^3 factorial experiment.

In the discussion of correlation and regression the simple concepts involved have been presented in terms of formulas for calculation. The concepts of curvilinear correlation and regression are also discussed and computation methods are given for multiple regression techniques.

(Continued on page 22)

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Books

(Continued from page 20)

The final chapter is a discussion of attribute statistics in which the use of chi-square, contingency tables and binomial probability are outlined.

Throughout this book, the examples used have been taken from the author's file and deal with the manufacture of products prepared by the du Pont Company. A little more latitude in the choice of examples might have made this book more acceptable to a wider variety of readers. The use of examples is frequent and fairly good; however, the documentation is extremely brief. Considerable utility could have been added by including footnotes along with the examples referring specifically to other sources of more detailed material or by expanding the bibliography to give the same information.

ROBERT G. TISCHER.

OMISSION RECTIFIED

The name of the reviewer of *Introductory Mycology* by Constantine John Alexopoulos was inadvertently omitted last month. The review, which appears under *Books*, page 15 of the March issue, was by Emil Mrak.

Selected Abstracts*

ANALYTICAL METHODS

Determination of sulfur dioxide by color-changing.

PATTERSON, G. D., AND MELLON, M. G. *Anal. Chem., 24,* 1586-9 (1952).

Several granular gels are described which change color when exposed to 150 ml. air samples contg. 10 p.p.m. of sulfur dioxide. The gel is placed in a glass tube and the air sample is drawn through the tube. Three methods of quant. estn. may be used. The colors which appear on the various gels may be matched with standard color cards; the length of a color column may be measured; or the sample volume necessary to produce a desired color or length of colored column may be observed. These gels provide a simple pocket-sized method for estg. physiologically dangerous concns. of sulfur dioxide in the atm.

Determination of arsenic in fruits and vegetables.

BARTLET, J. C., WOOD, M., AND CHAPMAN, R. A. *Anal. Chem., 24,* 1821-4 (1952).

The bromide distn. method of Magnuson and Watson has been adapted for the detn. of arsenic spray residues in fruits and vegetables. The 4-minute distn. time of the original method was found to be insufficient under certain conditions, and the procedure is modified by distg. to the appearance of thin fumes. Tin in canned fruits interfered with the detn. by distg. and pptg. as metastannic acid which absorbed a portion of the arsenic. This interference can be overcome by extg. the tin with cupferron and chloroform before distn. The method has been applied to canned fruit which contained appreciable amts. of tin, and to fresh fruits and vegetables. The arsenic content of representative samples of fruits and vegetables is given.

Determination of reactive hydrogen in organic compounds.

OLLEMAN, E. D. *Anal. Chem., 24,* 1425-39 (1952).

Methods for quantitatively detg. reactive hydrogen in org. compds. have been reviewed to find the most suitable procedures for estg. the reactive structural units in coal degradation products. In the past, reaction with methylmagnesium iodide or lithium aluminum hydride has been used to det. total accuracy of ± 3 to 5%. The types of compds. which have been detd. are: ales., phenols, enols, mercaptans, acids, amines, amides, and water. Acylation methods, including acetylation, phthaloylation, benzoylation, formylation, and stearylation, vary greatly among themselves and give results depending on reagents and conditions. Variations of the most common method i.e., acetylation using acetic anhydride and pyridine at approx. 100° C., have been used to det. primary and secondary ales. "unhindered" phenols, and primary and secondary amines. Other acylation reagents may be advantageous if tertiary alcs. or pyrroles must be detd. or selectivity of reaction is desired. Applicability of different acylation methods for detg. functional groups has been tabulated.

Use of ion exchange for separation of nitrogenous and other extractives of plant and animal tissues.

PARTRIDGE, S. M. *Anal. Chem., 24,* 1522 (1952).

A systematic procedure was outlined whereby the water-sol. extractives of plant and animal tissues are sepd. into groups for identification by paper chromatography or for quant. estn.

Recent advances in infra-red spectroscopic techniques.

SHEPPARD, N. *Analyst, 77,* 732-41 (1952).

An account is given of some recent advances in the design of infra-red spectrometers that seem likely to be incorporated in the future in instruments designed for analytical work. Some recent developments in micro-spectroscopy and high and low-temp. infra-red spectroscopy are briefly enumerated, and some effects of the change of state on the infra-red spectrum are mentioned.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Studies on the lipolytic enzyme action.

SCHONHEYDER, F., AND VOLQUARTZ, K. *Biochim. Biophys. Acta., 9,* 306-09 (1952).

A review of previous publications on the rate of hydrolysis of esters by lipolytic enzymes is given. The energies of activation for the hydrolysis of rac. 1-caprylyl glycerol in aq. homogeneous soln. by pancreatic lipase and liver esterase are found to be 9,200 cal/mole and 15,100 cal/mole resp. In a heterogeneous system which contains n-propyl caprylate and pancreatic lipase, no change in the initial reaction velocity with temps. 10.6° and 39.4° could be shown.

Enzymatic activities as indications of copper and iron deficiencies in plants.

BROWN, J. C., AND HENDRICKS, S. B. *Plant Physiol., 27,* 651-60 (1952).

Relative activities of ascorbic acid oxidase, catalase, and peroxidase were measured at two or three periods of growth for one variety each of corn, wheat, and tobacco, three species of lupines, and two varieties of soybeans grown on a soil of limited copper supplying capacity, another of limited iron supplying capacity and two mixts. of these soils. Ascorbic acid oxidase activity is markedly reduced by limited copper supply and is correlated with a reduction in yield for wheat in which it is a terminal oxidase. Catalase was reduced in relative activity for corn, tobacco, the lupines, and one variety of soybean when the iron supply was limited. The activity of peroxidase was more const.

Determination of oxidative enzymes and their inhibitors by a modified chromatographic method.

MAYER, R. L., GRIMM, M. R., AND KULL, F. C. *Proc. Soc. Exptl. Biol. Med., 81,* 163-4 (1952).

A simple method for the detn. of potato phenol oxidase and the quant. detn. of inhibitors to this and similar systems yielding color variations is described. Melanin is developed on filter paper sheets and anti-melanotic substances tested by a chromatograph, spray-like procedure.

The synthesis of sugars from simpler substances. Part III. Enzymic synthesis of a pentose.

HOUGH, L., AND JONES, J. K. N. *J. Chem. Soc.,* 4047-52 (1952).

(Continued on page 26 following technical papers)

* These Selected Abstracts are made available to FOOD TECHNOLOGY through the cooperation of Associate Editor H. A. Campbell and the General Foods Corporation of New York, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

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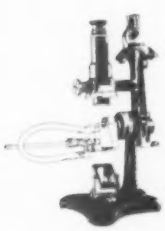

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Q. *Does Roche vitamin A have a "fishy" odor or taste?*

A. None whatever, nor is there any "fishy burp." In fact, Roche vitamin A has almost no odor or taste and so is preferred for processed foods such as margarine.

Q. *Will I be able to get a steady supply of Roche vitamin A?*

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Q. *Can I be sure of a "standard" product?*

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Q. *What about price?*

A. Roche vitamin A is not subject to wide fluctuation of price, as has been true with vitamin A from natural sources. This can mean large savings for you as there is no need to carry large inventories as was the case prior to the introduction of Roche vitamin A in 1950. Never before has the purchaser been assured of such low prices, consistent with quality and uniformity.

Q. *How is Roche vitamin A packed?*

A. All Roche vitamin A is packed under conditions which assure its stability in customary shipment and storage.

Q. *Can I get help from Roche in using vitamin A in my products?*

A. Yes, certainly! Roche technical experts who supplied so much data at the hearings for amended Definitions and Standards of Identity for Margarine are always at your service. It is important to you that Roche specializes in the manufacture of vitamins.

Q. *Is Roche vitamin A available in different types and potencies?*

A. It is. The following table shows the types most popular in food manufacturing.

TYPE	DESCRIPTION	POTENCY	ADDITIVE*
P1MO	Vitamin A palmitate	1,000,000 U.S.P. XIV units per gram	Edible oil only for standardization
P1.3	Vitamin A palmitate	Ranging between 1,250,000 and 1,500,000 U.S.P. XIV units per gram	None
A1MO	Vitamin A acetate	1,000,000 U.S.P. XIV units per gram	Edible oil only for standardization

*Antioxidants or other additives are included on customer's specifications.

Notes: Type P1MO has less tendency to crystallize during storage and handling than higher concentrations of vitamin A palmitate and acetate.

Type P1.3 is more susceptible to crystallization than type P1MO but can be handled without difficulty when using certain precautions.

Q. *Are special blends available for the margarine industry?*

A. Yes. Roche will supply blends to your specifications. A modern blending and canning plant is at your service.

Q. *What kind of service can I expect on special blends?*

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Bitterness in Navel Orange Juice

GEORGE L. MARSH
Department of Food Technology, University of California, Davis, California

(Manuscript received November 7, 1952)

A relationship between the rootstock and the organoleptic quality as measured subjectively by degrees of bitterness is shown to exist for fruits of the Navel orange. The rootstock upon which the fruit is grown appears to be a factor for consideration in evaluating the suitability of a variety for products use.

Navel oranges, an important crop in California, are regarded by many as superior to the Valencia for general use. Unfortunately, juice from the Navel orange cannot be used for canning, concentration, freezing, or other manufactured products. When extracted from the fruit now received by the products plants, the juice develops bitterness upon standing. This bitterness is a biochemical or physiological characteristic which renders the juice unsuitable for products use except in limited amounts for blending with other products of recognized and accepted bitter taste.

The bitter substance has been given considerable study. It has been isolated and subjected to intensive chemical *(4, 5, 7, 10, 15)* and physical *(11)* analyses. A few of its chemical properties are known, and some of them already form the basis of process patents directed toward the utilization of Navel orange juice. Much still remains to be learned, however, particularly with respect to the chemical structure of the bitter substance, the mechanism of its formation in extracted juice, and the chemical nature of the non-bitter precursor.

Other factors concerning this characteristic of the Navel orange have likewise been the object of considerable study. The degree or intensity of the bitter taste developing in the extracted juice is known to be a function of maturity, of pH, of heat, and of the length of time the juice is in contact with and the amount of other tissues incorporated during extraction.

It is now proposed to show that one additional factor can be added to this list, namely, the rootstock upon which the fruit was grown.

The effect of rootstock on the chemical composition of citrus fruits, and other fruits, has been studied in all the principal regions where fruits are grown. Sinclair and Bartholomew *(16)* adequately reviewed the older literature and contributed importantly to our knowledge of this subject with results from a carefully planned long-range study. Their data showed that with all 3 scion varieties tested the highest amount of chemical substance in peel, pulp and juice was found usually in fruits grown on the Morton-citrange, the Savage-citrange and the Trifoliate-orange rootstock; the lowest values were obtained from fruits grown on the Palestine sweet lime and the Rough-lemon rootstocks. Results for fruits grown on other rootstocks fell in between these extremes. Z. Samisch and Cohen *(14)* working with the Jaffa or Shamouti variety further confirm the results of previous investigators as regards the effect of rootstock on the chemical composition of the fruit. They conclude that the rootstock was the most important grove factor affecting fruit composition under normal cultural conditions, and that fruit from trees on the sour-orange rootstock appears to be superior to that grown on sweet lime rootstock with juice from the former containing, on the average, about 10% more sugar and 18% more citric acid as well as an increased amount of ascorbic acid.

Reynolds and Vaile *(12)* show similar findings for 3 varieties of American grapes. Their data demonstrate that significant differences in chemical composition of the fruit result from growth on different rootstocks. It was also noted that the 3 varieties did not respond similarly to the different rootstocks.

In an investigation on the effect of cover-crop treatment and rootstock on the chemical composition of the juice of 3 varieties of cider apples, Burroughs and Stanton *(3)* found that rootstock exerted a statistically significant effect on the nitrogen content and the total acidity of the juices. They also noted that the 3 varieties respond differently to the same rootstock.

Many similar references to previous works could be cited. All of these investigations, however, serve to establish that rootstock does, in most cases, affect the gross chemical composition of the fruit. Differences in composition affect the quality of the fruit and the products which can be manufactured from their juice. Although few would argue this fact, only one of the works cited attempted to correlate edible quality with growth on the different rootstocks. Unfortunately, edible quality is a subjective judgment not closely correlated with any objective tests so far devised. This is just as true for citrus juice products as it is for tea, coffee, and wines, whose edible qualities are solely determined by subjective methods. Flavor varies not only with change in gross chemical composition, but also and to a greater extent with changes in the complex interrelationships of the constituents present in minor concentration. Very little is yet known either as to the identity of these constituents or as to the role they assume in flavor perception.

At the time this experiment was planned, no chemical or physical test existed for determining bitterness in extracted Navel juice. Taste testing was considered the only practical means of conducting the work, particularly as it was also desired to determine the effect of the rootstock on the edible quality of the juice. The present investigator, however, has complete confidence in the results obtained by a trained and conscientious taster—a confidence developed from many years of critically tasting citrus juices and other products, especially wines. He considers the results obtained by tasting as reliable and just as sensitive for determining some constituents as the best quantitative procedures. Bitter substances are a good example.

PROCEDURE

Most of the data presented herein was secured by subjective methods during the 1948 and 1949 Navel seasons. Supplementary chemical analyses were made as time permitted on samples prepared for this purpose and preserved by storage at 0° F. (−17.8° C.).

Fruit for these studies was obtained from trees located in the experimental groves maintained by the Division of Subtropical Horticulture on the campus of the University of California at Los Angeles. They were trees of the Washington Navel variety grown on the following rootstocks: Sour-orange, Sweet-orange, Rough-lemon, Grapefruit, Trifoliate-orange, and a Navel-cutting, practically identified as tree 28 of Rows 7 to 12 inclusive in this experimental plot. The soil, cultural, and climatic variations are therefore as nearly constant as is experimentally possible for such a study.

The scion buds came from a single tree, and careful selection was likewise used in obtaining authentic rootstocks. Details on the procedures followed in obtaining the scion and rootstocks can be provided but are not considered essential to this report.

About 25 fruits of average size were picked from each of the marked trees at approximately bi-monthly intervals during each season. The fruits were washed, packed and shipped immediately by express to Berkeley, where they were processed as soon as received. The shipping time varied from 2 to 3 days, and the fruit deteriorated in quality to no greater extent, apparently, than is normal for this time period. It is recognized that a shorter time interval between picking and analysis is desirable, but all lots received the same treatment and the results obtained should, therefore, be comparable.

The fruits were halved with a stainless steel knife and the juice extracted by burring with a Blessing extractor. The burring heads were designed to reduce tearing of tissues to a minimum and were carefully selected for fruit size. Each fruit received as nearly the same pressure as is possible in hand burring practice.

The pulp was separated from the extracted juice by an aluminum plate containing 80 holes of 1 mm. dia. per square inch. The strained juice was deaerated by holding each lot of juice under a vacuum of 29 inches for 15 minutes with frequent shaking. In this experiment deaeration was employed, not for its usual purpose of retarding oxidative changes during processing and subsequent storage, but for removing the dissolved and occluded air which, if present, makes judgment of color and other changes difficult.

One hundred ml. quantities of the deaerated juice were then transferred to several wide-mouthed crown finished bottles of 120 ml. capacity. Care was used to prevent an undue amount of re-aeration. The bottles were coded and placed in storage at 0° F. for use as samples for chemical analyses. Finally, 200 mls. were placed in a 250 ml. beaker and covered with a watch glass to serve later as the sample for taste testing. Each lot of fruit, for each sampling period, for each of the two seasons, was handled as nearly identically as possible by the same person. The routine, once established, was adhered to without change.

The samples set aside for taste testing were examined at periodic intervals during the first 24 hours, and occasionally for even longer times. The first tasting occurred usually between 1 to 3 hours after extraction; a second tasting followed some 5 to 6 hours later; and a third during the early part of the following day. The samples were allowed to stand at room temperature (aver. 22° C.), covered only with a watch glass. After noting the cloudiness of the liquid portions of each sample they were stirred and tasted. Bitterness could have been just as well, perhaps more easily, evaluated without stirring, but it was also desired to judge the samples for general quality. Complete suspension of all suspendable matter is essential to a correct evaluation of general quality.

Samples of the different lots were withdrawn from freezing storage and analyzed for total solids, total acid, total sugars, reducing sugars, nitrogen, amino nitrogen, and ascorbic acid. In addition, the Brix degree, the refractive index and the pH value were determined.

Total solids were determined by drying an approximately 10 g. portion in vacuo for 16 hours at 70° C.; total acidity, expressed as anhydrous citric acid, by titrating a 10 ml. portion of the juice diluted with 200 ml. of hot water with a standard solution of NaOH, with phenolphthalin as the indicator.

The sugar determinations were made by the ceric sulfate method of Hassid *(8, 9)*. The nitrogen by a micro-method *(1)*, using the micro-Kjeldahl distillation apparatus designed by Kirk. Amino nitrogen was determined colorimetrically, using Folin's reagent by a method outlined by Sahyum *(13)*. The ascorbic acid was estimated by a 2,6,-dichlorophenol indophenol titration, using the procedure described by Evenden and Marsh *(6)*.

Brix was calculated from the specific gravity $\frac{20^\circ\text{ C.}}{20^\circ\text{ C.}}$ values determined by a chainomatic Westphal using the tables in the National Bureau of Standards *Bulletin C440*. A Leeds and Northrup research model glass electrode unit was used for determining the pH values.

RESULTS

The principal results of the tasting tests conducted on the many samples of juice prepared during this study are presented in tabular form in Table 1. By necessity it is brief, since a detailed report of the tasting records of each of the 72 samples would require too much space. The omitted facts can be developed descriptively in the text.

The remarkable influence of rootstock on the bitterness of extracted Navel orange juice is shown in the table. The first series of samples were graded from *no bitterness* to *extremely bitter*, after standing at room temperature from 18 to 24 hours. The non-bitter sample remained without bitterness for at least 60 hours, when it was finally discarded because fermentation and molding had set in. The sample grading *extremely bitter* developed bitterness within 5 minutes after extraction, those of intermediate bitterness requiring somewhat longer periods. No attempt was made to determine the time required for bitterness to become perceptible in the individual samples as the continued tasting required by such a program would cause the palate to fatigue.

Tasting of the subsequent series of samples received during the 1948 season changed the pattern only insofar as the bitterness decreased progressively as the fruit underwent the biochemical changes that accompany maturation. More samples at each testing period showed less tendency for the juice to become bitter, but the relative ranking within the group remained the same.

The tests were repeated in 1949 primarily because the 1947 growing season was peculiar in that nearly every fruit and vegetable variety ripened earlier than normally. This additional testing was necessary in order to determine whether the observed results were really indicative of a specific effect of the rootstock or merely due to unseasonable climatic effects.

As will be seen from the table, the tastings conducted in the 1949 season substantiated those of the previous season in nearly every respect. The first samples harvested in this series indicated that none of these rootstocks produces a truly non-bitter juice if the fruit is harvested at early maturity. The same marked graduation in bitterness between the juices extracted from the fruit grown on the different stocks was noted, however. The sample testing non-bitter in 1948 contained a trace of bitterness after standing for 23 hours at room temperature in the first series of samples tested in 1949. Bitterness was only questionably present in the juice from fruit on this stock by the second sampling which was approximately 2 weeks later.

DISCUSSION

It appears probable that the non-bitter precursor is present in the fruits of all Washington Navel oranges during the early formative periods, but to a greater or lesser degree, depending upon the rootstock. It disappeared at a more rapid rate during maturation from fruit grown on certain rootstocks than it did from fruit grown on others. In any event, by the time the fruit has reached commercial maturity the non-bitter precursor

TABLE 1

Summarized tabulation of organoleptic properties of juice from fruit grown on rootstock shown

Date Harvested	Sour Orange	Sweet Orange	Rough Lemon
1/6/48	1 h. (−) 18 h. (++++) oxid. Clear	2 h. (−) 22 h. (+) Clear	1 h. (++++) oxid. 20 h. (++++) clear
1/19/48	2 h. (−) 5 h. (−) 22 h. (++) v. stale	2 h. (+) 5 h. (+) 21 h. (++)	3 h. (++++) no aroma
2/2/48	3 h. (+) 24 h. (++) Stale odor	3 h. (−) 23 h. (+) fair aroma, stale flavor	3 h. (++++) 24 h. (++++) stale odor
2/19/48	1 h. (−) lacks aroma 21 h. (+) Stale oxid. flavor aroma	1 h. (−) good aroma and flavor 22 h. (+) fair aroma and flavor	1 h. (++++) no aroma 22 h. storage bin flavor
3/1/48	5 h. (−) fair aroma 24 h. (+) fair aroma; sl. stale flavor	5 h. (−) fair aroma 25 h. (−) sl. stale odor; fair flavor	5 h. (++++) fair aroma 25 h. (++++) no aroma or flavor
1/5/49	1 h. (++) lacks aroma 7 h. (++++) 24 h. (++++) oxid. flavor	1 h. (++) 7 h. (++++) 24 h. (++++) stale	2 h. (++++) no aroma 24 h. (++++) stale
1/18/49	2 h. (+) fair aroma 8 h. (+++) 22 h. (++++) flavorless	3 h. (+) 9 h. (++) 21 h. (++) fair flavor	3 h. (++++) 19 h. (++++) very stale and oxid.
2/2/49	3 h. (+) fair aroma; lacks flavor 22 h. (++) stale odor, no orange flavor	3 h. (+) fair aroma, no flavor 22 h. (++) stale odor, v. stale flavor	3 h. (++++) 19 h. (++++) very stale
2/15/49	3 h. (±) fair aroma; lacks flavor 22 h. (++) v. stale, no orange char.	4 h. (+) little aroma; fair flavor 20 h. (+) fair flavor	4 h. (++++) poor aroma 18 h. (++++) stale, haylike odor
3/2/49	22 h. (+) stale, aroma and flavor	21 h. (+) sl. stale odor and flavor	22 h. (++++) stale odor and flavor
3/16/49	24 h. (−) "processed" odor 72 h. (±) fermented	24 h. (−) stale odor, v. stale flavor 72 h. (−) fermented	24 h. (++++) v. stale odor 72 h. (++++) not fermented
3/29/49	24 h. (−) sl. "hay-like" aroma 72 h. (−) stale odor	24 h. (−) grass-like aroma and flavor 72 h. (−) fermented	24 h. (++++) fair aroma, some flavor 72 h. (++++) stale, ferm.

Date Harvested	Grapefruit	Trifoliate Orange	Navel Cutting
1/6/48	4 h. (−) 22 h. (−) 60 h. (−)	1 h. (−) 6 h. (+) 22 h. (+) cloudy	2 h. (−) sl. oxid. 5 h. (+) 24 h. (++) cloudy
1/19/48	3 h. (−) fair aroma 6 h. (−) 22 h. (−) sl. stale	3 h. (−) excel. aroma 23 h. (±) 30 h. (+) v. sl. stale	4 h. (−) 7 h. (+) 23 h. (+) v. stale
2/2/48	2 h. (−) fair aroma 6 h. (−) 22 h. (−) fair aroma, fairly good flavor	1 h. (−) good aroma, excel. flavor 5 h. (+) 22 h. (+) fair, fresh flavor	2 h. (−) 6 h. (−) staling 22 h. (−) stale odor, stale flavor
2/19/48	2 h. (−) fair aroma; good flavor 22 h. (−) sl. stale odor	2 h. (−) good aroma and flavor 23 h. (−) fair aroma and flavor	2 h. (−) little aroma, "processed taste" 22 h. (±) "haylike" odor; stale flavor
3/1/48	5 h. (−) good flavor 25 h. (−) fairly good flavor; lacks aroma	4 h. (−) excel. flavor, good aroma 24 h. (−) good flavor and aroma	3 h. (−) good flavor 23 h. (±) fairly fresh aroma, flavor
1/5/49	2 h. (−) fair aroma 7 h. (±) 23 h. (±)	2 h. (−) good aroma 5 h. (±) 20 h. (+) v. sl. stale	1 h. (−) little aroma 3 h. (±) 20 h. (++)
1/18/49	2 h. (−) fair aroma 8 h. (−) 19 h. (±) sl. stale	1 h. (−) good aroma 7 h. (+) 18 h. (+) v. sl. stale	1 h. (−) 7 h. (+) 18 h. (++) stale flavor
2/2/49	2 h. (−) fair aroma, good flavor 19 h. (±) sl. stale flavor	2 h. (−) good aroma, good flavor 18 h. (+) good aroma, fair flavor	2 h. (±) good aroma, little flavor 18 h. (++) stale odor, no orange flavor
2/15/49	4 h. (−) good aroma and flavor 18 h. (−) odor and flavor turning stale	4 h. (−) good aroma, good flavor 17 h. (±) fairly fresh aroma and flavor	3 h. (+) fair flavor 17 h. (++) stale odor, no orange flavor
3/2/49	19 h. (−) sl. stale odor and flavor	19 h. (−) good orange aroma and flavor	18 h. (+) fairly fresh aroma and flavor
3/16/49	24 h. (−) sl. stale odor 72 h. (−) fermented	24 h. (−) fresh aroma, good flavor 72 h. (−) fermented, fresh aroma	24 h. (+) stale odor and flavor 72 h. (+) fermented
3/29/49	24 h. (−) retained aroma and flavor 72 h. (−) fair aroma, fermented	24 h. (−) good aroma and flavor 72 h. (−) fresh odor, fermented	24 h. (±) fairly fresh 72 h. (+) v. sl. stale

Legend: (−) no bitterness, (±) bitterness doubtful, (+) slightly bitter, (++) bitter, (+++) strongly bitter, (++++) extremely bitter.

has nearly all disappeared from fruit grown on the grapefruit rootstock. Within a short period of weeks it has disappeared from the fruit grown on the Trifoliate-orange and Sweet-orange stocks. Only in late season did the non-bitter precursor completely disappear from the fruit grown on the Sour-orange rootstock and Navel-cutting rootstock. It never disappeared from fruit grown on the Rough-lemon stock and the juice from such fruits, after short periods of standing, tasted just as intensely bitter at the end of season as it did at the beginning.

That an alternative explanation could be suggested for the results on the basis of the data presented is not overlooked. Thus, since positive evidence is not presented to indicate the precursor of the bitter principle is absent in juice secured from fruits grown on the grapefruit rootstock, it is possible that it may in fact be present but reacting for some unknown reason at a markedly slower rate. Organoleptic observations made on the samples removed from freezing storage for chemical analysis tend to negate this possibility. Chemical analyses were begun in September 1949 and the most immature sample for each season had therefore been in storage for 21 and 9 months, respectively. Bitterness was absent in the 1948 sample from the grapefruit rootstock stored for 21 months; it presence was doubtful in the 1949 sample from the same rootstock. The complete testing of all samples at this period bore out similar relationships.

Moreover, experience gained from long association with research activities connected with Navel oranges and their products led to the adoption of the 24-hour test period for reporting results. Juice that does not bitter within this time period is not likely to become bitter when preserved by heat processing or freezing storage. That the flavorless precursor is lacking in oranges whose juice does not bitter after 24 hours of standing would therefore appear to be a logical assumption.

One of the Rough-lemon rootstock samples that had developed bitterness was used to determine the amount of dilution required to cause the bitterness to become imperceptible to the taste. At a dilution of 1 part in 7, bitterness was easily detectable, but at 1 part in 9 its detection by taste was questionable.

Flavor and aroma and the rate at which the stale, oxidized, or other off-odors and off-flavors developed were also noted. Edible quality, as evaluated by these factors, also proved to be affected by the rootstock. The quality pattern was different from the bitterness pattern, but was similar in many respects. Fruit grown on the Trifoliate-orange rootstock produced juice of excellent quality, possessing good aroma and flavor. It retained these characteristics with little or no change until the sample molded or fermented. This fruit also appears to have a weak or different pectic enzyme system, as the juice clears very slowly.

Fruit grown on the grapefruit rootstock and the Navel-cutting rootstock produced juice of good quality, possessing a fairly good aroma which tended to become stale after standing for 24 hours. These juices tended to be lacking in orange flavor. Juices produced from fruit grown on the Sour-orange and Sweet-orange rootstocks were only of fair quality initially, and developed the stale, "terpeney" flavor of preserved juice very rapidly.

The reader should be cautioned, however, from concluding that merely selecting fruit grown from a specific rootstock will solve all processing problems. This is particularly true for heat-preserved single strength juices where it has been shown *(2)* that some of the off-flavors developing during warm storage are due to interaction of components universally present in all fruits.

Although the fruit grown on the Rough-lemon stock resembled the other fruits in appearance and size—in fact, were their equal in this respect—the juice was different organoleptically. It developed bitterness rapidly, possessed little or no orange aroma and flavor and became stale very quickly on standing. Such a juice is unsuitable for conversion to any of the present juice products. Fruits grown on this stock may account for the uncertain behavior of packing-house lots of the Navel variety with respect to bitterness towards season's end. Packing house lots of fruit would be made worthless for products purposes by admixture of a very small percentage of fruits grown on this stock.

Only a small amount of the analytical data secured on the samples will be reported in tabular form. The analyses were made primarily for the purpose of determining whether some unsuspected abnormality was responsible for the results obtained from the tasting tests. The omitted data can be summarized by a few simple statements.

The Brix and the total acid values showed the normal trends obtained in a maturity study; the Brix increasing and the total acid values decreasing. There was no outstanding or consistent difference in the Brix degree of the juice from any of the stocks. The decrease in total acid concentration was lowest percentage-wise in the juice from fruits grown on the grapefruit rootstock. This occurred during both seasons and might prove significant. At any rate it caused the Brix-acid ratio of this juice to be lowest in each series of samples tested.

The sugar and nitrogen concentrations of the many samples analyzed are presented as seasonal averages in Table 2. The concentrations of both of these substances increases as the fruit becomes mature so that presenting the data as seasonal averages may not be wholly justifiable. On the other hand, the data serve to illustrate, summary-wise, the role rootstock plays in determining the concentration of these substances. It should be pointed out, also, that the higher values reported for the 1949 season are not ascribable to seasonal variation. They are caused by the 2 additional series of samples prepared from fruit received late in the 1949 season.

As previously reported, in the literature, rootstock appears to exert some minor effects on the composition of the juice. Both the sugar and nitrogen values vary from rootstock to rootstock, but not consistently from season to season. Of greater interest are the two ratios also shown in the table. The ratio, reducing sugar to total sugar, shows considerable consistency from season to season, and some, though slight, differences between the values reported for the different stocks.

TABLE 2

Effect of rootstock on the concentrations of sugar and nitrogen in Washington Navel juice (Seasonal averages)

Rootstock	Total sugars g./100 g.		Reducing sugars g./100 g.		Red sugar / Total sugar		Total nitrogen mg./ml.		Amino nitrogen mg./ml.		Amino N. / Total N.	
	1948[a]	1949[b]	1948	1949	1948	1949	1948	1949	1948	1949	1948	1949
Sour orange	9.01	8.91	3.91	3.84	.43	.43	1.193	1.400	0.418	0.518	.35	.37
Sweet orange	9.13	9.82	3.74	3.99	.41	.41	1.177	1.375	0.435	0.511	.37	.37
Rough lemon	8.63	10.21	3.45	4.05	.40	.40	1.263	1.559	0.460	0.595	.36	.38
Grapefruit	8.82	9.78	3.53	3.77	.40	.39	1.323	1.550	0.509	0.580	.38	.37
Trifoliate orange	9.60	10.04	4.03	4.04	.42	.40	1.365	1.586	0.469	0.558	.34	.35
Navel cutting	8.70	8.77	3.74	3.62	.43	.41	1.208	1.363	0.389	0.490	.32	.36

[a] 1948 values are averages of 5 samples submitted during the season.

[b] 1949 values are averages of 7 samples submitted during the season.

Further testing might prove that the rootstock produced statistically significant differences in this ratio. The amino N to total N ratio also shows good consistency from season to season, but no significant differences between the values reported for the different rootstocks. The futility of using chemical composition values for evaluating the effect of rootstock on edible quality is plainly apparent.

The work reported herein appears to open up an entirely new area for study. As already indicated, change in gross chemical composition in fruits grown on different rootstocks and the morphological manifestations of the rootstock on the scion have been recognized and used in practice, as, for example, in dwarfing. The physiological and biochemical manifestations of the rootstock on the scion have likewise come in for considerable study, and such studies form the basis for the recommendations used in selection of the proper rootstock. Edible quality, as determined by subjective evaluation, has been largely neglected, however, and receives no recognition, whatsoever, in the selection of rootstock. This applies to other genera as well as citrus.

In a way this failure to recognize the effect of rootstock on edible quality is understandable. Until recently, citrus fruit was grown primarily for eating out of hand. The trend now is toward conversion to products. Formerly the stress was of necessity on outward appearance—what was present inside was of minor importance, provided it was of good condition, and color, and was edible. Now the fruit must not only be of good condition and color, but it must also possess a good aroma and flavor and retain these desirable organoleptic properties during processing. In any studies involving the development and introduction of new varieties or the evaluation of old varieties, the organoleptic evolution of the fresh product and its ability of retaining these properties during processing must be included in the general plan. Teamwork by trained specialists in the different fields of study must be used to avoid costly mistakes in the future.

SUMMARY

The bitter substance limonin renders juice extracted from the Navel variety of orange unsuited for preservation by any known method.

Limonin forms in the extracted juice from an unknown non-bitter precursor as a result of a non-enzymatic reaction.

The rootstock was known to influence the gross chemical composition of many tree fruits and to exert other striking biochemical and physiological manifestations. Tests to determine the effect of rootstock on the concentrations of the factors involved in bittering were initiated and repeated for two growing seasons. These tests were by necessity of a subjective nature as analytical procedures did not exist for either the non-bitter precursor or the limonin.

A relationship was found to exist between the rootstock and the development of bitterness. Juice from fruit grown on the grapefruit rootstock develops no bitterness whereas juice from fruit grown on the rough-lemon rootstock becomes intensely bitter very soon following extraction. The other rootstocks tested (trifoliate-orange, sweet-orange, sour-orange, navel-cutting) were intermediate in their effect on bitter development.

Similarly, a relationship was found to exist between rootstock and other organoleptic properties of the juice. The overall quality of the juice from fruit grown on the trifoliate-orange was superior to all others. Very wide differences existed in this respect.

The data secured by chemical analysis were not indicative of the wide difference existing in the degree of bitterness nor in the other differences shown by the subjective testing.

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LITERATURE CITED

1. Barker, H. A. *Univ. of Calif. Syllabus for Soils III.* (1948).
2. Blair, J. S., Godar, E. M., Masters, J. E., and Riestar, D. W. Exploratory experiments to identify some of the chemical reactions causing flavor deterioration during storage of canned orange juice. 1950. American Can Co., Maywood, Illinois.
3. Burroughs, L. F., and Stanton, W. R. Factors affecting juice composition and cider quality of fruit from bush trees. I. The effect of cover-crop and rootstock on the

composition of the juice. Agr. and Hort. Res. Sta., Bristol, *Ann. Rept.* (1947).
4. Emerson, O. H. The bitter principles of citrus fruit. I. Isolation of Nomilin, a new bitter principle from the seeds of oranges and lemons. *J. Am. Chem. Soc.*, **70**, 545 (1948).
5. Emerson, O. H. The bitter principle in navel oranges. *Food Technol.*, **3**, 248 (1949).
6. Evenden, W., and Marsh, G. L. Effect of storage temperature on retention of ascorbic acid in orange juice. *Food Research*, **13**, 244 (1948).
7. Geissman, T. A., and Tulagin, V. Some observations on the structure of limonin. *J. Org. Chem.*, **11**, 760 (1946).
8. Hassid, W. Z. Determination of reducing sugars and sucrose in plant materials. *Ind. Eng. Chem., Anal. Ed.*, **8**, 138 (1936).
9. Hassid, W. Z. Determination of sugars in plants. *Ind. Eng. Chem., Anal. Ed.*, **9**, 228 (1937).
10. Higby, R. H. The bitter constituents of Navel and Valencia oranges. *J. Am. Chem. Soc.*, **60**, 3013 (1938).
11. Jones, F. T., and Palmer, K. J. Optical, crystallographic, and X-ray diffraction data for limonin and some of its solvates. *J. Am. Chem. Soc.*, **71**, 1935 (1949).
12. Reynolds, H., and Vaile, J. E. Effects of rootstock upon composition and quality of fruit of Concord, Campbell and Moore Early grapes. Ark. Agr. Expt. Sta., *Bull.*, **421** (1942).
13. Sahyun, M. Outline of the Amino Acids and Proteins. 1944, Reinhold Pub. Co., N. Y.
14. Samisch, Z., and Cohen, A. Composition of oranges in Israel. Jewish Agency, Palestine Agr. Res. Sta., Rehovot, *Bull.*, **51** (1949).
15. Seshadri, T. R. Chemical investigations of Indian fruits. IV. Bitter principle of a variety of Citrus limetta. *Proc. Indian Acad. Sci.*, **18A**, 201 (1943).
16. Sinclair, W. B., and Bartholomew, E. T. Effects of rootstock and environment on the composition of oranges and grapefruit. *Hilgardia*, **16**, 125 (1944).

What Federal Agencies Are Doing in Poultry Dressing Sanitation[a]

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Activities of 4 federal agencies concerned with poultry dressing sanitation are described. Correlation of the work of one agency with that of another is shown. Insofar as is required a unified program of sanitary control is conducted by the Food and Drug Administration, the Public Health Service, the U. S. Department of Agriculture and the Department of Defense. The interest of the public is protected by official regulations, inspection and grading services (which are self-supporting) and by assistance to state and local agencies in setting up sanitary control programs at these levels. There is law enforcement with regard to the wholesomeness, freedom from disease, improper processing, and misbranding of poultry in interstate commerce and in plants providing poultry that is shipped through interstate channels. Each of the 4 agencies operates under the authority of a specific public law, referenced in this study, and it is shown that overlapping of activities and duplication of effort are prevented.

Interest of Federal agencies in the problem of food plant sanitation has developed rapidly in recent years. Growth of the food processing industry, and the shift from home or small establishment methods of handling food to the large-production-line type of food processing has brought about a need for organized and sound sanitation programs in the production of foodstuffs. Although the principal emphasis on sanitation has been often in the field of public health, there is wide interest among many other groups in the protection of quality, elimination of spoilage and the aesthetic value of producing food under clean, wholesome and sanitary conditions.

The various Federal agencies have become concerned in poultry dressing sanitation through the functions that they perform. In some cases interest has developed through rendering certain services, in others through protecting the interest of the public, and in still others through the function of protecting the interest of Federal agencies making purchases under specification. Each agency operates according to delegations of authority under a specific public law. Thus, the field of activity of each agency is outlined, the particular interest defined and the method of carrying out the assignment is specified. This prevents overlapping of activities, duplication of effort, and keeps the cost of carrying out the programs at a minimum.

Although the fields of activities are clearly separated there is evidence of close cooperation—of working together to prevent misunderstandings. There is frequent consultation between agencies to clarify objectives, to interpret regulations, to define terms, and to establish the reasonableness of contemplated action either alone or in cooperation with other agencies. In certain cases the services and regulations of one group are accepted by another Federal agency in carrying out its program.

Inspection of poultry meat is not covered by the regulations governing meat inspection by the U. S. Department of Agriculture. There is no compulsion that poultry dressing plants must be under the supervision of any Federal agency. The Federal agencies come into the picture only when there is a voluntary request for poultry inspection or grading services, when the product is produced under Federal Purchase Specifications for sale to a governmental agency, or when action is taken to protect the public interest against filthy, decomposed or adulterated food products.

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The purpose of this paper is to set forth what the various agencies are doing in the field of poultry dressing sanitation and to indicate how the various programs are carried out.

FOOD AND DRUG ADMINISTRATION

This agency operates under authority of the Federal Food, Drug and Cosmetic Act *(1)*. The program is nationwide and concerned with poultry products in interstate commerce, or products being processed for that prupose. It does not cover products processed and sold within a state. The principal aim is to protect the public interest by preventing the movement in interstate commerce of birds that are diseased, improperly processed, filthy, decomposed, or in any way injurious to health *(2)*. One portion of the authority concerns factory inspection *(3)* with regard to sanitation and conditions of processing. This insures that products intended for interstate shipment are produced under sanitary and wholesome conditions.

Market surveys are regularly made to determine the quality and condition of the poultry products being sold. If a quality determination reveals up-grading, action is taken under the section of the law covering Misbranding *(4)*. If filthy, diseased or decomposed products are found, or if it is revealed that birds have died other than by slaughter, action is taken by seizure of the product—and prosecution follows. Tracing the interstate shipment and making a sanitary survey of the plant where the processing took place may ensue.

In addition a regular program of sanitary inspection of poultry plants is carried out. Inspectors calling at a plant are concerned with the operation, equipment, sanitation and the condition of the final product. As a guide to the inspection a set of instructions in the form of a "14-point" program is used. This sets forth the points that should be covered in the inspection, the reason for determining the existing conditions and the interpretations of the observations.

The inspector makes the plant survey in the interest of protecting the public, but he is also of assistance to the processor in keeping his plant in order. The plant operator, or anyone designated by him, is at liberty to accompany the inspector through the plant, and they are advised wherein any operation is in conflict with the law. If the inspector makes the survey alone he advises the management of any objectionable conditions before leaving the plant. If during the plant inspection conditions are found that may result in the contamination of the product, prosecution and/or injunction proceedings may be instituted.

Inspectors carrying out this work are given extensive training in sanitation and are made familiar with the methods and techniques used in the dressing and handling of poultry. They are trained not only in making observations but also in collecting samples, in making photographs, and in obtaining material for bacterial and chemical analysis that will support legal action taken against poultry products believed unfit for sale under the law.

The Food and Drug Administration operates on a regional basis, but all proposals for legal action against poultry or against poultry packers are referred to the Washington, D. C. office for clearance. In this way the same yardstick of action is applied to all sections.

There is close coordination with other Federal agencies with regard to compliance with the Food, Drug and Cosmetic Act in carrying out inspection, grading, purchase, or research programs, in the uniform interpretation of terms and definitions, and in the dissemination of information to the public.

PUBLIC HEALTH SERVICE

The work of this agency is largely of a cooperative and advisory nature *(5)* and is not concerned with a direct food-inspection program. The service is charged with enforcement of the Interstate Quarantine Regulations *(6)*. The section concerning the serving of food aboard interstate carriers *(7)* provides for inspecting the source of the food supply *(8)*. If unfit poultry products were served aboard an interstate carrier, an inspection of the processing plant of origin could be ordered to determine if it had been processed under proper and sanitary conditions.

The Public Health Service provides advisory, informational, and consultative services to other Federal agencies, the States, their political subdivisions, and food industries, with regard to public-health and sanitation programs. Frequent requests have come from local and State regulatory agencies for information on recommended sanitary control procedures in the processing of poultry and poultry products. Similar requests also have been received from members of the poultry-processing industries.

Feeling that there is a need for a standard ordinance governing poultry-processing operations, and an accompanying code of interpretation, the Service has initiated field studies on the sanitation problems of the poultry industry. The project, which is supervised by a veterinary officer, has as its major objective the protection of the consuming public from food-borne diseases associated with poultry and poultry dishes. The cooperation of industry and State and local regulatory agencies is being sought in the interest of obtaining background information which will prove helpful in providing assistance in the promulgation of sound control programs.

As planned, the Service will develop sanitation standards, covering inspection for wholesomeness, which can be incorporated into a standard ordinance. This document will later be tested, on a demonstration basis, in several selected States and communities, to determine its workability and applicability. It must be emphasized that this publication, like all other standard ordinances of the Public Health Service, is designed for voluntary adoption by States, cities, and other jurisdictions concerned. A traditional major objective of the Public Health Service is to obtain wide agreement on the provisions of all ordinances and codes that it offers for adoption, even though they are never used as the basis of an over-all Federal enforcement program.

The Public Health Service prepares visual aids and develops plans for sanitation training programs pertaining to subjects covered by their recommended standards. Recently, personnel of this Service participated as staff members in the poultry-sanitation schools held under the supervision of the Department of Agriculture. Also, they cooperated in the final development of the "Sanitary Requirements" *(10)* under which the Department of Agriculture operates its inspection and grading service.

U. S. DEPARTMENT OF AGRICULTURE

The poultry sanitation work of the U. S. Department of Agriculture is centered primarily in the Poultry Branch of the Production and Marketing Administration, and may be divided into (a) poultry inspection, (b) poultry grading, and (c) poultry processing research. The first two are services provided by the Poultry Inspection and Grading Division, and the last is carried out in the Research Division.

U.S.D.A. poultry inspection and grading services have been available for almost 35 years. These services are not compulsory and are extended to individuals, processing plants, or other financially interested parties. They are performed only when the applicant complies with the provisions of the grading and inspection regulations, and are withdrawn whenever there is evidence of failure to comply.

The present authority for rendering the Poultry Grading and Inspection services is contained in the Agricultural Marketing Act of 1946 *(9)*, and the regulations set forth as Part 70 of the Code of Federal Regulations *(11)*. Upon receiving an application for services an official survey of the plant is made with regard to the adequacy of equipment and facilities to handle the work, the design and arrangement for carrying out a sanitation program, and guarding against contamination of products, etc. If all parts of the plant are adequate the service is granted and it becomes an "Official Plant." All products brought into or processed in an official plant must be handled in accordance with the sanitary requirements *(10)*.

The inspection and grading services are on a self-supporting basis, and are not services rendered by a governmental agency from appropriated funds. The applicant agrees to pay the costs incurred and to comply with the various regulations.

The purpose of "poultry inspection" is to determine, during the eviscerating operation, the condition, healthfulness and fitness

of poultry for human food, and the wholesomeness of edible parts or processed product produced from inspected poultry. In addition to the inspection of carcasses for freedom from disease and the determination of wholesomeness, the sanitation program and plant operation is under the supervision of the Veterinarian in charge.

"Poultry grading" involves the sorting of individual carcasses as to quality and size, and the determination of class and condition. The entire plant operation must be in accordance with the requirements for sanitation, facilities and operating procedures.

The requirements as to sanitation, facilities and operating procedures have applied to plants under poultry inspection service for many years, but became applicable to poultry dressing operations on July 1, 1951. Prior to that time the requirements had applied primarily to the eviscerating, packing, and certain other auxiliary rooms, but did not cover other parts of the plant. Under the new regulations all parts of an official plant used in connection with the operation must be equipped and operated in compliance with the sanitary standards. This applies not only in those plants under the supervision of a Veterinary inspector, but also those official plants in which only grading is done; or where poultry is dressed for subsequent handling in another official plant.

This means that all poultry products eligible to bear official identification marks must be produced under sanitary supervision throughout the process. The plant in which the poultry is killed and dressed must be under sanitary supervision even though the poultry is to be eviscerated or graded in another plant many miles away. Such a system insures that the products will be handled in a clean and sanitary manner throughout the entire processing and handling procedures.

The type of services where sanitary requirements are enforced include:

a. Inspection of dressed poultry during evisceration and preparation as ready-to-cook.
b. Inspection of poultry for canning and supervision of canning operations.
c. Certification of dressed poultry produced under U.S.D.A. sanitary standards.
d. Grading of dressed poultry.
e. Grading of ready-to-cook poultry.

The sanitary provisions are considered as minimum standards; they are designed to insure that buildings are kept clean, free of rodents and insects, that drainage and plumbing systems are adequate, that equipment is designed, constructed and arranged to permit thorough cleaning, that the operating procedures conserve quality, prevent contamination and deterioration, and that the requirements are practicable in operation.

Requests for services have increased in recent years, and at the time of this report October 1952, it is estimated that during 1952 approximately 781,846,900 pounds of poultry products will be inspected for condition and wholesomeness, and that approximately 1,460,000,000 pounds of poultry will be processed under the U.S.D.A. sanitary requirements.

Personnel used in these programs are well trained for the job. Inspection of poultry carcasses is carried out by graduate Veterinarians. When any lay personnel are used, they are under the supervision of a Veterinarian. The operation of dressing plants is under trained sanitarians. Within the past year 10 sanitation schools have been held in various parts of the U. S. The average attendance at each of these schools was between 50 and 60 people. The purpose was to give thorough ground work in the services to be rendered, and to acquaint the staff with the fundamental problems of sanitation. Members of the teaching staff were drawn from colleges and experiment stations, and from various services of the Federal Government. These schools will be held each year to keep the staff informed of current developments and to train new personnel.

Research on poultry plant sanitation is carried out by the Poultry Branch in cooperation with industry. A Mobile Laboratory Unit is used and processing plants become the laboratories in which operational research is conducted. Recent research on the use of in-plant-chlorination *(12)* in poultry dressing has pointed to the lowering of bacterial populations on the surface of the birds. Also, the use of mechanical washing equipment, and the advantageous placement of such equipment in the plant, have been shown to improve the sanitary quality of dressed poultry.

The research involves studies on the scalding, picking, singeing and chilling of dressed birds, the washing, eviscerating, cutting up and packaging of ready-to-cook poultry, with the major objectives of improving the sanitary techniques with which each operation is carried out.

DEPARTMENT OF DEFENSE

The poultry sanitation program in this Department is centered on the procurement of poultry meat for the Armed Forces. During 1951 approximately 118,000,000 pounds of chickens and turkeys were procured for the Armed Forces; all of it was produced under rigid sanitary standards according to military specifications and under the sanitary supervision of the Army or Air Force Veterinary Corps.

The Veterinary Service, Office of the Surgeon General, is charged with the responsibility for making inspections pertaining to foods of animal origin *(13)*, with the object of protecting the health of troops against disease transmitted through spoiled, damaged, or contaminated foodstuffs, and protecting the financial interests of the Government. The Veterinary Service *(14)* must pass on the sanitary condition of the plants, the conditions of manufacture and the quality of the delivered products, as well as on the product at destination and during storage. Such a program insures the delivery to the Armed Forces of clean, wholesome poultry meat of good sanitary history and of the quality specified in contracts.

A vendor proposing to bid on an Armed Forces contract must apply to the procuring agency for a Veterinary inspection of his establishment *(15)*. If the plant and its equipment and the methods used conform to the approved principles of sanitation of The Surgeon General, Department of the Army, and to the technical requirements contained in the purchase specifications, the plant is placed on an approved list. Awarding of contracts is limited to approved plants or those operating under the U.S.D.A. Poultry Inspection Service.

If only dressed poultry is produced, the operation must be carried out under the supervision of the Veterinary Corps. However, if various types of ready-to-cook or canned poultry products are being produced the plant must be operated under the supervision of the Poultry Inspection Service of the U. S. Department of Agriculture *(16)*, and automatically the sanitary requirements of that Service applied. However, the actual inspection of the product is a responsibility of the Veterinary Corps. In this case there is complete cooperation between the concerned Governmental Agencies, in that the services of one group are accepted, or required, in carrying out the duties of the other group. Also, there is integration with the activities of the Food and Drug Administration since all deliveries to the Armed Forces must conform in every respect with the provisions of the Federal Food, Drug and Cosmetic Act *(1)*.

Officers and enlisted men carrying out the inspection duties mentioned above undergo intensive training in the Army Medical Service Meat and Dairy Hygiene School in Chicago. A portion of the training concerns the supervision of sanitation programs. Upon completion of the school the personnel is usually given on-the-line training in poultry processing plants before being given full responsibility for supervising the activities in a plant.

The Office of The Quartermaster General is charged with the development and promulgation of specifications or standards for the procurement of food items. Into the specifications are woven the basic requirements to be used in processing the item. An example of this is the military specification for dressed and ready-to-cook chickens *(17)*, which provides for the inspection of the product during processing, packing, packaging, and for condition and quantity at destination by the Veterinary Corps.

SUMMARY

Each of the 4 agencies concerned with poultry dressing sanitation works in a field defined and authorized by specific laws. The activities of each is correlated with

that of the other agencies insofar as it is desirable and necessary to obtain a unified program in the interest of the public. Services for inspection and grading of poultry are available upon request, and these services are self-supporting and voluntary programs. The requests for such services have markedly increased in recent years. Governmental poultry procurement programs carry the requirement of inspection and sanitary supervision by authorized Veterinarians.

There is law enforcement with regard to the wholesomeness, freedom from disease, improper processing, and misbranding of poultry in interstate commerce and the sanitation in plants providing such poultry. Poultry processed and sold within a state is not subject to such a program. States and local agencies may receive assistance in setting up sanitary control programs.

LITERATURE CITED

1. *Federal Food, Drug and Cosmetic Act*, (21 USC 301), Public—No. 717, Seventy-fifth Congress, Chapter 675, Third Session, 55; June 1938.
2. *Ibid.*, Section 402, (a), Adulterated Food.
3. *Ibid.*, Section 704, Factory Inspection.
4. *Ibid.*, Section 403, Misbranding Food.
5. General powers and duties of public health service, Title III, Part A Sec. 301; Part B. Sec. 311, 314, *Public Health Service Act.*
6. Interstate quarantine regulations, Part 72, Title 42, Code of Federal Regulations, as amended March 3, 1951; (16 F.R. 2037).
7. *Ibid.*, Section 72.163, General requirements.
8. *Ibid.*, Section 72.164, Source of food and drink; identification and inspection.
9. Provisions relating to poultry inspection and grading: 60 Stat. 1087; 7 USC 1621 *et seq.*, *Agricultural Marketing Act of 1946.*
10. Regulations governing the grading and inspection of poultry and edible products thereof and United States Classes, Standards and Grades with respect thereto, Part 70 of the Code of Federal Regulations, *Federal Register*, June 5, 1951 and April 24, 1952. Section 70.39, Minimum standards for sanitation, facilities and operating procedures in official plants.
11. Regulations governing the grading and inspection of poultry and edible products thereof and United States classes, Stands and Grades with respect thereto. Part 70 of the Code of Federal Regulations, *Federal Register*, June 5, 1951, and April 24, 1952.
12. Goresline, Harry E., Howe, Milton A., Bausch, Edward R., and Gunderson, Millard G. In-plant chlorination does a 3-way job. *U. S. Egg and Poultry Magazine*, **57** (4) April 1951.
13. *Veterinary Meat and Dairy Hygiene.* General, 1. Authority. Army Regulations No. 40-950, Air Force Regulations No. 160-21; 29 April 1949.
14. *Veterinary Meat and Dairy Hygiene.* General, 2. Scope. C2, AR 40-950, AFR 160-21A, 4 April 1952.
15. *Veterinary Meat and Dairy Hygiene.* General, Section I, Inspection of Establishments. Special Regulations No. 40-950-1, Air Force Regulations No. 160-22; 29 April 1952.
16. *Veterinary Meat and Dairy Hygiene.* General, 1. Scope, C, (2), (b); C3, AR 40-950-1, AFR 160-220; 4 April 1052.
17. *U. S. Department of Defense, Military Specifications.* Chickens, dressed; and Chickens ready-to-cook, MIL-C-10467A; 9 January 1952.

An Application of Oxidation-Reduction Potentials to Frozen Fruits Treated With Ascorbic Acid and Ascorbic-Citric Acid Mixtures[a]

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A means of evaluating the effectiveness of ascorbic acid and ascorbic-citric acid mixtures in controlling oxidative changes during freezer storage of Bing cherries, J. H. Hale peaches and Italian prunes is described. The evaluation is based on oxidation-reduction potentials calculated from pH, and reduced and oxidized ascorbic acid values determined for the experimental lots of treated fruit.

Oxidative changes in frozen fruit packs have caused considerable concern among frozen food packers and investigators alike. These changes are characterized by the development of undesirable color and flavor during freezer storage and subsequent thawing.

Several means for control of these oxidative changes have been suggested in the literature *(1, 6, 7, 8, 10, 11, 13, 15, 16)*. These are: lowering pH to inactivate enzyme activity; forcing respiration to utilize available oxygen; replacing oxygen in the product tissue by syrup impregnation; freezing the product immediately after its preparation; storing the frozen product below 0° F. (−17.8° C.); selecting suitable varieties; blanching; and using sugar syrups with and without antioxidants, such as sulphurous acid, thiourea, ascorbic acid and ascorbic-citric acid mixtures.

How can the effectiveness of these methods be evaluated? The most common means have been based on the ascorbic acid content of the product and on a color and organoleptic evaluation.

The objective in this study was to evaluate the effectiveness of ascorbic acid and ascorbic-citric acid mixtures in controlling oxidative changes during freezer storage of Bing cherries, J. H. Hale peaches and Italian prunes. The evaluation was based on oxidation-reduction (OR) potentials calculated from the pH, and the reduced and oxidized ascorbic acid values determined for the experimental lots.

When ascorbic acid is reversibly oxidized, an exchange of 2 electrons takes place and the over-all reaction may be written:

$$\begin{bmatrix}\text{Reduced}\\ \text{Ascorbic Acid}\end{bmatrix} \rightleftharpoons \begin{bmatrix}\text{Oxidized}\\ \text{Ascorbic Acid}\end{bmatrix} + 2e + 2H^+$$

Under equilibrium conditions this reversible reaction should exhibit a stable oxidation-reduction potential. Although some early workers were not able to demon-

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strate a stable potential, careful experiments by others *(3, 5, 11)* have indicated a reversible reaction, when the pH of the medium is taken into consideration. Since reduced ascorbic acid is a weak acid, the oxidation-reduction potential is influenced by the pH of the solution. Borsook and Keighley *(3)* found that, at a given pH between 2.0 and 5.75, the observed potentials in solutions of pure ascorbic acid fit an equation developed on thermodynamic grounds which treats the ascorbic acid as a monovalent weak acid. Ghosh and Rama Char *(5)* calculated the value of E_o in the following thermodynamic equation [c]

$$E_h = E_o - \frac{RT}{F} pH + \frac{RT}{2F} \log \frac{(\text{dehydroascorbic acid})}{(\text{reduced ascorbic acid})} \qquad (1)$$

where E_h was measured electrometrically. E_o values calculated for a wide variety of concentration ratios and pH conditions were found to be essentially constant with an average of 0.370 v.

Since the biochemical systems in products of a biological nature such as fruits are very complex, an over-all condition approaching a "steady state" rather than individual equilibria must be visualized. This "steady state" oxidatively spans the range from reducing substrate in the fruit to oxygen from air. Considering ascorbic acid as an intermediary OR system, the OR potential calculated on the basis of amounts of reduced and oxidized ascorbic acids present would reflect the condition of the "steady state" which respect to oxidative changes, although the ascorbic acid system itself may not be in chemical equilibrium and consequently may not yield the potential electrometrically.

[c] A factor of 2.303 is required to convert from $\log_e$ to $\log_{10}$, a factor which these authors incorporated in their calculations, without noting in the equation. T is the absolute temperature; R is 1.987 calories per degree-mole when F is 23,060 calories per volt.

In this investigation, the amount of reduced and oxidized ascorbic acid in the fruit and syrup was determined after the packages had been stored at 0° F. (—17.8° C.) for 6 months. The pH of the fruit and syrup was also measured. Oxidation-reduction potentials were calculated from these data, using equation I, and the oxidation-reduction state estimated from the calculated curves of Figure I.

EXPERIMENTAL PROCEDURE AND RESULTS

The fruits used were packaged in 40° Brix sucrose syrup. A weighed amount of ascorbic acid per lb. of fruit was dissolved in a measured amount of the syrup just previous to packaging the fruit and syrup. The antioxidants used were crystalline ascorbic acid U.S.P.[d], a laboratory mixture of ascorbic and citric acids, and 2 commercially prepared mixtures of ascorbic and citric acids.[e] The levels of ascorbic acid and the ratios of ascorbic to citric acid in the mixtures varied to some extent, depending on the fruit with which they were used. The specific treatments are presented in Tables 1 and 2.

The prepared fruits and syrups were individually weighed into cellophane bags. The bags were then heat-sealed and placed in individual cardboard boxes. To freeze the syruped fruits, the packages were placed in still air at 0° F. (—17.8° C.). Not more than a half hour elapsed between preparation of the fruit and placing the packaged products in the freezer. Bing cherries and Italian prunes were packed in 40° Brix syrup, 284 g. of fruit to 170 g. of syrup. The J. H. Hale peaches were packed in the same concentration of syrup, 311 g. of fruit being packed in 143 g. of syrup.

The amounts of ascorbic acid (both reduced and total) retained after 6 months' storage were determined for 3 samples of a fruit and syrup mixture from each of 2 packages representing each treatment. Essentially the methods of ascorbic acid analysis outlined by Loeffler and Ponting *(9)* and Bessey *(2)* were used for reduced ascorbic acid and total ascorbic acid, respectively. In addition to the ascorbic acid analysis the pH of the fruit and syrup mixture was determined and the fruit was visually examined for color retention.

The logarithm of the ratio of oxidized ascorbic acid to reduced ascorbic acid was calculated for each lot of treated fruit. The E_h or characteristic potential of each lot of treated fruit was calculated from equation I, using the log of the ratio of

[d] Manufactured by Hoffman La Roche Inc.
[e] Manufactured by Chas. Pfizer and Co., Inc.

TABLE 1

Average values for ascorbic acid and pH of experimental lots of fruit after 6 months of freezer storage

Level of added ascorbic acid mg. per lb.	No added citric acid			0.1% citric acid added			0.2% citric acid added			Commercial mixes			
	Ascorbic acid mg. per pkg.		pH	Ascorbic acid mg. per pkg.		pH	Ascorbic acid mg. per pkg.		pH	Ascorbic acid mg. per pkg.			
	Reduced	Dehydro		Reduced	Dehydro		Reduced	Dehydro		Mix	Reduced	Dehydro	pH
Bing Cherries													
0	2.54	23.79	4.26	.....	.....	.....	.....	.....	.....	4/96[f]	23.10	29.52	3.86
150	46.94	15.68	4.28	36.69	.....	4.24	34.50	15.11	4.12				
250	90.48	21.72	4.22	75.71	20.39	4.16	86.56	45.59	4.04				
350	130.26	21.76	4.22	110.88	53.75	4.16	123.39	37.79	4.04				
450	208.67	22.45	4.23	.....	.....	.....	.....	.....	.....	8/92[g]	28.62	14.52	3.89
J. H. Hale Peaches													
0	8.80	16.00	3.98	.....	.....	.....	.....	.....	.....	4/96	51.15	21.87	3.59
150	52.66	14.68	3.90	84.56	22.83	4.05	80.18	23.21	3.95				
250	147.29	21.49	3.94	135.21	13.85	4.07	131.86	11.30	3.67				
350	180.95	21.89	3.94	155.38	15.82	3.97	181.19	21.99	3.97				
450	257.70	23.06	4.02	.....	.....	.....	.....	.....	.....	8/92	63.43	20.41	3.64
Italian Prunes													
0	0.0	10.18	3.52	.....	.....	.....	.....	.....	.....	4/96	0.0	23.13	3.54
150	25.04	51.84	3.64	8.80	74.70	3.28	5.03	72.98	3.22				
250	69.68	61.91	3.70	12.06	70.09	3.12	24.88	65.00	3.06				
350	71.89	95.71	3.44	.....	.....	.....	.....	.....	.....				
450	185.07	35.16	3.39	.....	.....	.....	.....	.....	.....	8/92	0.0	41.07	3.48

[f] Four percent ascorbic acid and 96% citric acid added 0.45% of fruit weight.
[g] Eight percent ascorbic acid and 92% citric acid added 0.35% of fruit weight.

TABLE 2

Calculated E_h potentials and conditions of "steady states" [b]

Level of added ascorbic acid mg. per lb.	No added citric acid		0.1% citric acid added		0.2% citric acid added		Commercial mixes		
	E_h Potential	"Steady State"	E_h Potential	"Steady State"	E_h Potential	"Steady State"	Mix Type	E_h Potential	"Steady State"
Bing Cherries									
0	0.179	O	—	—	—	—	4/96	0.172	P
150	0.141	P	—	—	0.152	P			
250	0.141	R	0.145	P	0.158	P			
350	0.137	R	0.152	P	0.153	P			
450	0.131	R	—	—	—	—	8/92	0.166	P
J. H. Hale Peaches									
0	0.175	P	—	—	—	—	4/96	0.180	P
150	0.158	P	0.151	P	0.156	P			
250	0.149	R	0.139	R	0.157	R			
350	0.149	R	0.144	R	0.146	R			
450	0.139	R	—	—	—	—	8/92	0.173	P
Italian Prunes									
0	∞	O	—	—	—	—	4/96	∞	O
150	0.194	P	0.227	O	0.227	O			
250	0.181	P	0.232	O	0.226	P			
350	0.198	P	—	—	—	—			
450	0.016	R	—	—	—	—	8/92	∞	O

[b] "Steady State" is indicated by the symbols, O, P, R, which mean oxidizing, poising and reducing, respectively.

oxidized to reduced ascorbic acid, the pH values and the standard electrode potential found by Ghosh and Rama Char *(5)*. A graph presenting calculated E_h potentials covering the range from a nearly complete oxidizing state to a nearly complete reducing one at pH 3.00 and at pH 4.30 was drafted (Figure 1). These pH values (3.00 and 4.30) bracket the range of pH found to occur in these fruits. Arbitrary values (20% and 80% oxidized ascorbic acid) were chosen to represent the point of change of state from reducing to poising and poising to oxidizing, respectively. Heavy vertical lines were drawn to indicate the separation between the three states of the system, reducing, poising and oxidizing.

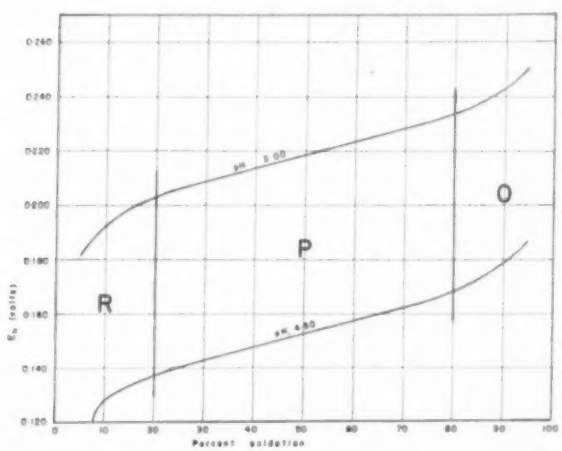

Figure 1. Calculated E_h values between pH 3.00 and 4.30 for the range of 5% oxidation to 95% oxidation of reduced ascorbic acid. E_o = 0.370 volts. Arbitrary oxidizing, poising and reducing areas noted by O, P and R, respectively.

The results of the analyses to determine the amounts of reduced and dehydroascorbic acid retained in each lot of these treated fruits are presented in Table 1 along with the corresponding pH. These ascorbic acid data represent the average of 3 determinations, for both reduced and total ascorbic acid, from each lot of treated fruit. The E_h potentials for each lot of treated fruit were calculated from these data. The calculated potentials, along with the designation of "state" of the system for each lot of treated fruit, are presented in Table 2. By referring to Figure 1, the state of the system for any E_h potential presented in Table 2 was designated either O for oxidizing, P for poising or R for reducing.

In view of these data, each lot of treated fruit was evaluated for effectiveness in controlling oxidative changes in the fruit during freezer storage and subsequent thawing.

Bing cherries. When ascorbic acid was added alone, the results indicated a change from an oxidizing state in the untreated fruit to a poising state, with the addition of ascorbic acid at the rate of 150 mg. per lb. of fruit. Increased amounts of added ascorbic acid decreased the E_h potentials gradually, changing the oxidative system to a reducing state.

When citric acid was used with the added ascorbic acid, the reducing state was not maintained, but a poising state obtained. Thus, added citric acid provided less protection against oxidation in the cherries than that provided by the same level of ascorbic acid used alone. Unfortunately, the experimental value was missed for dehydroascorbic acid in the case of 150 mg. of ascorbic acid with 0.1% citric acid.

Both commercial mixtures of ascorbic and citric acids maintained the oxidative system in Bing cherries in a poising state, as judged from the calculated E_h potentials.

J. H. Hale peaches. The E_h potentials, calculated for the treatments applied to J. H. Hale peaches indicated that, as the amount of ascorbic acid added to the package of fruit and syrup was increased, the effectiveness of the antioxidant treatment in retarding oxidative changes increased. The change from a poising state to a reducing state occurred between 150 and 250 mg. added ascorbic acid.

As in the case of Bing cherries, citric acid used in combination with ascorbic acid was of no additional value over and above the same level of ascorbic acid used alone in retarding the oxidative changes.

Both commercial mixtures maintained the J. H. Hale peaches in a poising state, indicating a protection of the order of that provided by 150 mg. of ascorbic acid alone.

Italian prunes. The E_h potentials calculated for the lots of prunes treated with varying amounts of ascorbic acid alone, did not consistently decrease as the amount of added ascorbic acid was increased. The lot of prunes containing no added ascorbic acid contained no natural, reduced ascorbic acid, so that the E_h value for this was a positive infinity. Keeping this in mind, the lots of fruit containing added ascorbic acid were superior in retarding the oxidative processes to the control lot of fruit containing no added ascorbic acid. However, there appeared to be no additional effect of retarding the oxidative processes when the higher levels of ascorbic acid were applied to the fruit, except where ascorbic acid was added at the rate of 450 mg. per lb. of fruit. In this instance the resulting E_h potential was very low

indicating exceptionally good protection against oxidation of the product.

The addition of citric acid in combination with ascorbic acid resulted in higher E_h potentials than was the case in lots of fruit treated with ascorbic acid alone. These potentials were high enough to indicate an oxidizing state, in contrast to the poising state provided by the ascorbic acid alone.

The lots of fruit treated with the commercial mixture contained no reduced ascorbic acid when the fruit was analyzed after 6 months' storage. Thus the E_h potentials were positive infinity, indicating the lowest possible protection against oxidative changes in frozen prunes treated with these mixtures.

Color examinations. When each of these lots of treated fruits was examined for color retention and rated on a scale of one to 10 by a panel of judges, the resulting averages of the judges' decisions tended to support the trends indicated in the evaluation of antioxidant treatments by use of the calculated E_h potential values.

CONCLUSIONS

1. Under the conditions of these experiments, a characteristic oxidation-reduction potential may be calculated from the equation:

$$E_h \text{ (volts)} = 0.370 - \frac{2.3\,RT}{F}\,pH + \frac{2.3\,RT}{2F}\log_{10}\frac{(\text{dehydroascorbic acid})}{(\text{reduced ascorbic acid})}$$

2. The effectiveness of the antioxidants used may be estimated from these oxidation-reduction potentials.

3. For the Bing cherries and the J. H. Hale peaches, a minimum of 150 mg. of added ascorbic acid per lb. of fruit is indicated for adequate protection against oxidative changes. This minimum is 350 mg. per lb. of fruit for Italian prunes.

4. The use of citric acid in combination with the ascorbic acid and the use of the commercial mixes of these acids are not as effective in maintaining a reducing environment as is ascorbic acid alone. The difference is greatest in the case of Italian prunes.

5. A change from 0.1% to 0.2% citric acid does not appreciably alter the status of the oxidative systems.

SUMMARY

This study was designed to evaluate the effectiveness of ascorbic acid alone and in combination with citric acid when they are used to retard oxidative changes in Bing cherries, J. H. Hale peaches and Italian prunes during freezer storage.

The fruit used was packed in 40° Brix sucrose syrup containing the dissolved antioxidant in the prescribed concentrations.

The fruit and syrup were analyzed for ascorbic acid (both reduced and total) after the packaged fruit had been stored for 6 months at 0° F. (—17.8° C.).

The characteristic oxidation-reduction potential (E_h value) was calculated for each lot of treated fruit. Arbitrary limits were set up on the basis of the percent of oxidized ascorbic acid and these limits were used to designate each lot of fruit as being a reducing, poising, or oxidizing medium after 6 months' storage.

The effectiveness of the various treatments in retarding oxidative changes was estimated on the basis of the arbitrary potential limits.

Trends which the E_h values indicated for oxidative changes were supported by visual estimation of color changes.

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LITERATURE CITED

1. Bauernfeind, J. C., and Siemers, G. F. Retardation of discoloration in frozen sliced peaches by l-ascorbic acid. *Quick Frozen Foods*, **7**, 46 (1945).
2. Bessey, O. A. The Bessey method for determination of ascorbic and dehydroascorbic acid in animal and plant tissue. *J. Biol. Chem.*, **126**, 771 (1938).
3. Borsook, H., and Keighley, G. Oxidation-reduction potentials of ascorbic acid (Vitamin C). *Proc. Nat. Acad. of Sci.*, **19**, 875 (1933).
4. Getman, F. H., and Daniels, F. *Outlines of Physical Chemistry*. 7th Ed., 1941, John Wiley and Sons, Inc., New York.
5. Ghosh, J. G., and Rama Char, T. L. Das Oxydations-Reduktions-Potential der Ascorbinsaure (Vitamin C). *Z. Physiol. Chem.*, **246**, 115 (1937).
6. Hohl, L. A. Preparation and pretreatment of fruits for freezing. *Food Freezing*, **1**, 287 (1946).
7. Joslyn, M. A. Treatments for discoloration of apricots in freezing. *Ice and Refrigeration*, **90**, 388 (1936).
8. Joslyn, M. A. Preservation freezing of apricots for subsequent processing by bakers, baby food firms and others. *Western Canner and Packer*, **34**, 34 (1942).
9. Loeffer, H. H., and Ponting, J. D. Ascorbic acid. Rapid determination in fresh, frozen or dehydrated fruits and vegetables. *Ind. Eng. Chem., Anal. Ed.*, **14**, 846 (1942).
10. Luther, H. G., and Cragwall, G. O. Ascorbic-citric acids prevent browning of cut fruits. *Food Inds.*, **18**, 690 (1946).
11. Rogers, A. J. How to quick freeze cherries successfully. *Refrig. Eng.*, **40**, 215 (1940).
12. Rosenbert, H. R. *Chemistry and Physiology of the Vitamins*. 1942, Interscience Publishers, Inc., New York.
13. Tressler, D. K., and Dubois, C. W. No browning of cut fruit. *Food Inds.*, **16**, 701 (1944).
14. Truton, J. S. Oxidation-reduction potentials of ascorbic acid. *J. Biol. Chem.*, **105**, 79 (1934).
15. Wiegand, E. H. Oxidation and its control. *Quick Frozen Foods*, **8**, 81 (1946).
16. Woodroof, J. G. Browning action of oxidase enzymes on catechol tannins. *Food Inds.*, **12**, 35 (1940).

Coliform Bacteria from Orange Concentrate and Damaged Oranges

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Evidence is presented to show that of 217 coliform cultures obtained from orange concentrate and damaged oranges and grouped in accordance with their IMVIC test reactions, 64% were Escherichia coli types, 19% were Aerobacter aerogenes types, and 17% were intermediate types. Of the E. coli types 41% gave IMVIC patterns considered of sanitary significance.

Bacteria found in citrus products and contaminating the surface of processing plant equipment have been much discussed because many of them have been identified as coliform bacteria. Data reported in this paper are from a study begun in the 1949-50 fruit season and continued through the 1950-51 season. The objective was to learn more about the prevalence of coliforms[c] in citrus products, particularly those organisms commonly suggested to be of sanitary significance.

Despite wide interest in the subject, the literature on coliform contamination in orange juice products is not extensive. Nolte and von Loesecke *(10)*, Teunisson and Hall *(18)*, Patrick *(13)*, Wolford and Berry *(23, 24)*, have reported coliforms as significant contaminants. Of these investigators, Wolford and Berry *(24)*, isolated *E. coli;* Teunisson and Hall *(18)*, isolated *Aerobacter aerogenes*. Aerobacter types were found more often by all of the investigators than were intermediate forms.

In view of the present knowledge of frozen food microbiology there is good reason to believe that coliforms are not more likely to survive than other nonsporeforming bacteria for long periods in frozen juice or concentrates. Certainly they were not found in numbers equal to those present in the fresh product. It is evident from the work of Shrader and Johnson *(15)*, McFarlane *(9)*, Martinez and Appleman *(7)*, Wolford and Berry *(23)*, Wolford *(25)*, and Wallace and Tanner *(21)*, that some cells do survive for varying intervals in storage. Hahn and Appleman *(4)*, failed to isolate *E. coli* from orange juice that had been inoculated artificially after 24 hours in a frozen state. They noted that *Streptococcus faecalis* survived for a much longer period. Kaplan and Appleman *(6)*, isolated coli-like bacteria and enterococci from commercially packed orange concentrate and suggested that enterococci might serve better than *E. coli* as an indicator of pollution in frozen food. Hahn and Appleman *(5)* observed that the organic acid molecule and pH were important factors affecting the survival of enteric bacteria in frozen citrus concentrates. Cold pressed peel oil exerted a toxic effect on *Str. faecalis*.

High temperatures have been found to be even more detrimental to these bacteria than low. Faville, Hill and Parish *(2)*, were unable to demonstrate by plate method, live *E. coli* inoculated artificially into 42° Brix concentrate after 15 minutes incubation at 39° or 40° C. Smith and Gillmore *(16)* reported that *E. coli* survived for 4 hours in 42° Brix orange concentrate at 37.5° C. Patrick *(13)* was unable to recover *E. coli* from artificially inoculated orange juice after 4 days at room temperature.

Relatively little of the more than 21.5 million gallons or the more than 30.5 million gallons respectively of concentrate prepared in each season involved in this study *(17)* was subjected to pasteurization temperatures. In most plants, however, the fruit surfaces were effectively washed with chlorinated water, detergents, and other rinses. Processing equipment was similarly cleaned, but the numbers of microorganisms per ml. of juice in the different samples prepared in a given plant did not always bear a close relationship with the known sanitation of the plant equipment, but were more often related to the quality of fruit used *(3, 14)*. Wolford and Berry *(23)* had concluded sometime earlier that "Elimination of unsound fruit is obviously of prime importance in the production of frozen orange juice of low microbial count and coliform index."

EXPERIMENTAL PROCEDURE

Of the 217 coliform cultures involved in this study, 192 were isolated from samples of 42° Brix concentrate. Most of these had been frozen to a slush-ice preparatory to canning and freezing. The remaining 25 cultures were isolated from lots of juice extracted separately from damaged oranges that had burst, but did not show evidence of fermentation or decay.

Those isolates which produce a metallic sheen on Levine's eosin methylene blue agar (E.M.B.) and fermented lactose broth were purified; their IMVIC[d] characteristics were determined by tests described by the American Public Health Association *(1)*. The Voges-Proskauer tests were also checked by the method of Werkman *(22)*. The following miscellaneous tests to differentiate coliforms were also made according to recommended procedures; Eijkman lactose broth test at 46° C. (Perry's modification), nitrate reduction, lactose fermentation, gelatin liquefaction, and Gram stain *(1)*; Vaughn and Levine buffered boric acid lactose test at 43° C. *(19)*; cellobiose, salacin, sucrose, starch, glycerin, and inositol fermentations, hydrogen sulfide production (peptone iron agar) *(20)*. Not all of the miscellaneous tests mentioned were run each year on all cultures.

RESULTS

Cultural characteristics of the organisms isolated during the 1949-50 and 1950-51 fruit seasons are presented in Tables I and

[a] Resigned August 29, 1952.

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[c] The term *coliform* is used here to designate Gram negative, lactose-fermenting, non-sporeforming rods.

[d] IMVIC. "(I) Indole production; (M) Methyl red reaction; (V) Voges-Proskauer test; and (IC) the utilization of citrate as a sole source of carbon," Parr *(12)*.

TABLE 1

Numbers of coliform cultures responding to IMVIC and miscellaneous tests (1949-50)

Types	IMVIC tests[a]				Miscellaneous tests[b]								
	In.	M.R.	V.P.	Cit.	Eijk.	Nit.	Uric.	Ura.	Cel.	Sal.	Su.	Star.	Inos.
E. coli types (94 cultures)	20+	20+	20—	20—	20+	20+	18+ 2—	20+	4+ 16—	18+ 2—	18+ 2—	15+ 5—	20—
	1—	1+	1— +[c]	1—	1+	1+	1+	1+	1+	—	—	1+	1+
	73+	73—	73—	73—	73+	73+	73+	73—	25+ 48—	—	—	73+	73+
A. aerogenes types (25 cultures)	21—	21—	21+	21+	6+ 15—	21+	21+	21—	21+	—	—	21+	21+
	4—	4—	4—	4+	3+ 1—	4+	4+	4—	4+	—	—	4+	4+
Intermediate types (20 cultures)	4—	4+	4—	4+	4—	4+	4+	4+	4+	—	—	4+	4+
	13—	13—	13—	13—	12+ 1—	13+	13+	13—	4+ 9—	—	—	13+	4+ 9—
	1+	1—	1—	1+	1—	1+	1+	1—	1—	—	—	1+	1+
	2+	2—	2+	2+	2—	2+	2+	2—	1+ 1—	—	—	2+	2+

[a] In. — Indole
M.R. — Methyl red
V.P. — Voges-Proskauer
Cit. — Citrate

[b] Eijk. — Eijkman-lactose, 46° C.
Nit. — Nitrate
Uric. — Uric acid
Ura. — Uracil
Cel. — Cellobiose
Sal. — Salicin
Su. — Sucrose
Star. — Starch
Inos. — Inositol

[c] Variable reaction

2, arranged in the order of the 16 possible combinations listed by Parr *(11, 12)* for the 4 tests involved in establishing the IMVIC reactions.

It is seen from the tables that by using Parr's *(11, 12)* scheme and grouping the 217 cultures according to their IMVIC reactions, they are assembled into 3 major groups as follows:

Types	1949-50	1950-51	Total
E. coli types	94 (68%)	45 (58%)	139 (64%)
A. aerogenes types	25 (18%)	16 (20%)	41 (19%)
Intermediate types	20 (14%)	17 (22%)	37 (17%)
Total	139	78	217

The largest group composed of 139 cultures gave typical and atypical *E. coli* reactions with the IMVIC tests, but contained only two that were in agreement in all respects with the reactions of type cultures of *E. coli*. All cultures gave negative responses to hydrogen sulfide and Gram's stain tests and positive responses to the lactose fermentation test.

DISCUSSION

The tabulated data illustrate some of the difficulties encountered in the attempt to classify and attach sanitary significance to bacteria isolated from citrus fruit and citrus fruit products on the basis of their peculiar ability to produce a metallic sheen on Levine's eosin methylene blue agar and to ferment lactose broth. Although differential tests other than those reported in this paper were run as indicated above, only two (1%) of the cultures isolated were confirmed in all tests to be *E. coli*. Nevertheless many of them must be considered as variant strains of *E. coli* if importance is to be attached to their IMVIC patterns and to their reactions in Eijkman's lactose medium (Perry's modification) at 46° C., in Vaughn and Levine's buffered boric acid lactose medium at 43° C., in cellobiose and in other media used for generic differentiation purposes.

According to the American Public Health Association *(1)* those coliforms showing the IMVIC patterns + + — — and — + — — are commonly designated as *E. coli* varieties from fecal sources. If this is true, other members of the coliform group were more prevalent among these cultures; there were 57 (26.2%) that gave these 2 IMVIC patterns. The 57 cultures constitute 41% of the *E. coli* types as indicated by this grouping.

A. aerogenes and intermediate types were found in the minority, possibly because only those colonies were picked from E. M. B. plates for further study which possessed the metallic sheen characteristically produced by coli.

Notwithstanding classification difficulties, the use of the completed coliform test routinely has been of service to the citrus industry in that it has been instrumental in bringing about better sanitary conditions in processing plants and in showing the need for selecting fruits of good quality for processing. Most juice dealers and consumers do not fully appreciate the fact that the low pH (3.4 to 3.8) and relatively high acidities (0.5% to 1.2%) of orange concentrates, together with the high solids content, are unfavorable for the survival and propagation of coliforms, even under favorable temperature conditions. Moreover, conditions are being made even more unfavorable for the survival of coliform bacteria in concentrates produced in Florida by the present increasing trend to heat treat concentrates for stabilization purposes.

SUMMARY

Cultural characteristics of 217 coliform bacteria isolated from orange concentrate and damaged oranges were studied. The bacteria were grouped according to their IMVIC test reactions into *Escherichia coli* types

TABLE 2

Numbers of coliform cultures responding to IMVIC and miscellaneous tests (1950-51)

Types	IMVIC tests [b]				Miscellaneous tests [c]									
	In.	M.R.	V.P.	Cit.	Eijk.	Bor.	Nit.	Uric.	Gel.	Cel.	Sal.	Su.	Star.	Glyc.
E. coli types (45 cultures)	15+	15+	15−	15−	15−	8+ 7−	15+	15+	15−	4+ 11−	9+ 6−	11+ 4−	8+ 7−	15+
	17+	17+	17−	17−	17+	10+ 7−	17+	17+	17−	7+ 10−	17+	11+ 6−	11+ 6−	17+
	4−	4+	4−	4−	2+ 2−	2+ 2−	4+	4+	4−	1+ 3−	3+ 1−	4+	3+ 1−	4+
	9+	9−	9−	9−	8+ 1−	4+ 5−	8+ 1−	9+	9−	1+ 8−	7+ 2−	6+ 3−	7+ 2−	9+
A. aerogenes types (16 cultures)	8−	8−	8+	8+	8−	1+ 7−	8+	8+	5+ 3−	7+ 1−	6+ 2−	6+ 2−	5+ 3−	8+
	4−	4−	4+	4−	4−	4−	4+	1+ 3−	2+ 2−	4+	4+	3+ 1−	4−	4+
	4−	4−	4−	4+	4−	4+	2+ 2−	4+	1+ 3−	4+	3+ 1−	3+ 1−	1+ 3−	4+
Intermediate types (17 cultures)	1+	1+	1−	1+	1−	1−	1+	1+	1−	1−	1+	1−	1+	1+
	2−	2+	2−	2+	2−	2−	2+	2+	2−	2+	2+	2+	1+ 1−	2−
	13−	13−	13−	13−	1+ 12−	1+ 12−	3+ 10−	2+ 11−	5+ 8−	1+ 12−	3+ 10−	6+ 7−	13−	7+ 6−
	1+	1−	1−	1+	1−	1−	1+	1−	1−	1+	1+	1+	1+	1+

[b] In. — Indole
M.R. — Methyl red
V.P. — Voges Proskauer
Cit. — Citrate

[c] Eijk. — Eijkman lactose, 46° C.
Bor. — Boric acid lactose, 43° C.
Nit. — Nitrate
Uric. — Uric acid
Gel. — Gelatin
Cel. — Cellobiose
Sal. — Salicin
Su. — Sucrose
Star. — Starch
Glyc. — Glycerine

(139 cultures, 64%), *Aerobacter aerogenes* types (41 cultures, 19%), and intermediate types (37 cultures, 17%). Fifty-seven (41%) of the 139 *E. coli* types gave the IMVIC patterns + + − − and − + − − which are considered of sanitary significance. *A. aerogenes* and intermediate types were isolated in the minority, possibly because only those colonies which were coli-like in appearance were selected from eosin methylene blue agar plates for further study.

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LITERATURE CITED

1. American Public Health Association. *Standard Methods for the Examination of Water and Sewage*. 9th Ed., 1946, New York, N. Y.
2. Faville, L. W., Hill, E. C., and Parish, E. C. Survival of microorganisms in concentrated orange juice. *Food Technol.*, **5**, 33 (1951).
3. Faville, L. W., and Hill, E. C. Incidents and significance of microorganisms in citrus juices. *Food Technol.*, **5**, 423 (1951).
4. Hahn, Saul S., and Appleman, M. D. Microbiology of frozen orange concentrates. I. Survival of enteric organisms in frozen orange concentrate. *Food Technol.*, **6**, 156 (1952).
5. Hahn, Saul S., and Appleman, M. D. Microbiology of frozen concentrate. II. Factors influencing the survival of microorganisms in frozen orange concentrate. *Food Technol.*, **6**, 165 (1952).
6. Kaplan, Milton T., and Appleman, M. D. Microbiology of frozen orange concentrate. III. Studies of enterococci in frozen concentrated orange juice. *Food Technol.*, **6**, 167 (1952).
7. Martinez, J., and Appleman, M. D. Certain inaccuracies in the determination of coliforms in frozen orange juice. *Food Technol.*, **3**, 392 (1949).
8. Mitchell, N. B., and Levine, M. Nitrogen availability as an aid in the differentiation of bacteria in the coli-aerogenes group. *J. Bact.*, **36**, 587 (1938).
9. McFarlane, V. H. Behavior of microorganisms in fruit juices and in fruit juice-sucrose solutions stored at −17.8° C. (0° F.). *Food Research*, **7**, 509 (1942).
10. Nolte, A. J., and von Loesecke, H. W. Types of organisms surviving in commercially pasteurized citrus juices in Florida. *Food Research*, **5**, 73 (1940).
11. Parr, L. W. Coliform intermediates in human feces. *J. Bact.*, **36**, 1 (1938).
12. Parr, L. W. Coliform bacteria. *Bact. Revs.*, **3**, 1 (1939).
13. Patrick, R. Bacteriological survey of some citrus canneries in Florida with special attention to *Escherichia coli*. *Proc. Florida State Hort. Soc.*, **60**, 36 (1947).
14. Patrick, R. Microbiological surveys of citrus processing plants during the 1948-49 season. Southern Regional Research Laboratory, U. S. Dept. Agr., Agr. Research Admin., AIC **259** (1950).
15. Shrader, J. H., and Johnson, A. H. Freezing orange juice. *Ind. Eng. Chem.*, **26**, 869 (1934).
16. Smith, A. B., and Gillmore, J. D. Bacteriological study of concentrated orange juice. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland. Project NM Oil *Report No. 1* (1947).
17. Shuler, P. E., and Townsend, Jr., J. C. Florida citrus fruit, annual summary. Bureau of Agriculture Economics, U. S. Dept. Agr., **4**, 39 (1951).
18. Teunisson, D. J., and Hall, H. H. Study of bacteria from citrus processing operations in relation to orange juice quality. *Fruit Products J.*, **26**, 199 (1947).
19. Vaughn, R. H., and Levine, Max. Effect of temperature and boric acid on gas production in the colon group. *J. Bact.*, **29**, 24 (1935).
20. Vaughn, R. H., and Levine, Max. Differentiation of the "Intermediate" coli like bacteria. *J. Bact.*, **44**, 487 (1942).
21. Wallace, G. I., and Tanner, F. W. Microbiology of frozen foods. III. Longevity of pure cultures of bacteria in various menstrua. *Fruit Products J.*, **14**, 235 (1935).
22. Werkman, C. H. An improved technique for the Voges Proskauer test. *J. Bact.*, **20**, 121 (1930).
23. Wolford, E. R., and Berry, J. A. Condition of oranges as affecting bacterial content of frozen juice with emphasis on coliform organisms. *Food Research*, **13**, 172 (1948).
24. Wolford, E. R., and Berry, J. A. Bacteriology of slime in a citrus processing plant with special reference to coliforms. *Food Research*, **13**, 340 (1948).
25. Wolford, E. R. Bacteriological studies on frozen orange juice stored at −10° F. *Food Technol.*, **4**, 241 (1950).

Effects of Processing Variables on Leaching Loss, Carotene Content, and Susceptibility to Browning in Dehydrated Carrot

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Effects of blanching time, of spray with sulfite solution or with water, and of heat damage at the end of the drying cycle have been studied. Leaching losses of 5 to 12% of weight of dry product (moisture-free basis) were caused by the spray with water or sulfite solution (1¼ pounds of solution per pound of carrot). Under the extreme conditions of 90 minutes of soaking following blanching, the leaching losses were over 50% of product weight. Leaching reduced the rate of browning during subsequent storage of the dried product. Heat damage during drying increased somewhat the rate of browning during storage. Carotene content remained substantially constant during processing.

Knowledge of the effects of processing variables is important to the dehydration industry from the standpoint of both production capacity and storage stability. The work reported here was conducted to determine the effects of (a) blanching time, (b) spray with water or with sulfite solution during or after blanching, and (c) heat damage at the end of drying on leaching losses, carotene retention, and resistance to browning during storage at 38° C. (100° F.).

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MATERIAL AND METHODS

Red Core Chantenay carrots were peeled by abrasion, trimmed, cut to ⅛ x ⅜ x $^{3}/_{16}$-inch size, washed in turbulent water for 1 minute to remove fines, and centrifuged for 2 minutes to remove surface water. They were immediately loaded (1½ pounds/sq. ft.) on wooden slat trays lined with 16-mesh galvanized screen. Except for the unblanched samples, they were then blanched on the trays in steam at 212° F. (100° C.) for the designated time (Table 1). To prevent mechanical loss, the trays were covered with screen during blanching. Each lot consisted of 25 pounds of the diced centrifuged carrots.

Certain of the lots were sprayed with water or sulfite solution (0.2% sodium metabisulfite plus 0.2% sodium sulfite) during or after blanching. The amount of water or sulfite solution was 1.5 pounds per pound of raw carrot; it was applied in a period of 7 to 10 seconds. As an extreme condition other lots were soaked in cool (ca. 20° C., 68° F.) agitated water for 90 minutes.

Most of the samples were dried for 8 hours in a cabinet-type drier at a dry-bulb temperature of 150° F. (65.5° C.) and a wet-bulb temperature of 85° to 90° F. (29.5° to 32° C.). For samples dried under heat-damaging conditions, the above conditions were used for the first 5 hours; this was followed by 2 hours at

TABLE 1

Effects of processing variables on leaching losses, carotene content and susceptibility to browning

Blanching time	Processing Spray	Leaching loss	Carotene change during processing[c]	SO_2 (initial) MFB	H_2O MFB	Days for given degree of browning[d] "Low"	"Medium"
(Min.)		%	%	*p.p.m.*	%		
0	None	1.5	−8	0	6.2	54 (51)[e]	>150
2	None	1.2	−6	0	6.8	42 (44)	124 (131)
	H_2O spray during blanching	14.8	−14	0	6.3	64 (61)	>150
	H_2O spray after blanching	9.6	−11	0	6.5	53 (53)	>150
	Sulfite spray during blanching	12.5	+6	2300	6.4	103 (101)	>150
	Sulfite spray after blanching	10.0	+11	2650	6.2	116 (109)	>150
4	None	3.4	−11	0	6.6	42 (43)	127 (129)
	H_2O spray during blanching	14.2	−3	0	6.3	50 (48)	150 (144)
	H_2O spray after blanching	12.7	−5	0	6.6	48 (49)	143 (145)
	Sulfite spray during blanching	13.6	+3	2300	6.1	98 (90)	>150
	Sulfite spray after blanching	10.2	+9	2350	6.2	97 (91)	>150
8	None	3.6	−11	0	6.7	41 (43)	120 (129)
	H_2O spray during blanching	16.2	−4	0	6.7	54 (56)	>150
	H_2O spray after blanching	9.9	−4	0	6.6	53 (54)	>150
	Sulfite spray during blanching	13.5	+3	1700	6.3	126 (121)	>150
	Sulfite spray after blanching	7.8	−1	2250	6.0	126 (115)	>150
4	90-min. soak after blanching	55.4	.....	0	5.8	>150	>150
	90-min. soak after blanching, then H_2O spray	55.4	.....	0	6.5	>150	>150
	90-min. soak after blanching then sulfite spray	54.0	.....	3200	5.7	>150	>150

[c] Apparent gain (+) or (loss (−) during blanching, washing, and drying.

[d] "Low" and "medium" degrees of browning correspond to optical density increases of 0.120 and 0.360 unit, respectively, for extracts prepared, with 2.5 grams dehydrated carrot per 100 ml. water, with color measured in a 2 cm. cell at 420 mμ. An optical density increase of 0.600 unit corresponds to the previously selected "limit of palatability" *(6)*.

[e] Values in parentheses represent the values at 6.5% moisture, with moisture correction by use of browning rate-moisture data of a previous publication *(5)*.

200° F. (93° C.) dry bulb, with a wet bulb temperature of 140° F. (60° C.).[1]

To permit calculation of leaching losses, the weights and moisture contents of the material after centrifuging, and after drying, were carefully determined. For the dry material, moisture content was measured by the 40-hour vacuum oven method of Makower, Chastain, and Nielsen *(7)*. For the wet material, moisture content was determined by a two-stage operation, the first stage being a 24-hour vacuum drying of the dice (oven temperature 100° F., 38° C.) and the second stage the 40-hour vacuum oven procedure. Carotene was determined by the method of Dutton, Bailey, and Kohake *(2)*.

For determination of rate of browning during storage, portions of each lot were adjusted to about 6.5% moisture, MFB (moisture-free basis). This adjustment was accomplished in vacuum desiccators containing the carrot samples together with small perforated metal boxes in which the appropriate amount of water had been frozen prior to placement in the desiccator. The carrots were then canned (100 g. per 211 x 414 can), nitrogen-packed (1.5 ± 0.5% O_2), and placed in storage at 100° F. (38° C.). Samples were removed periodically and the degree of browning measured by the "soluble color" procedure *(4)*, in which the optical densities of suitably clarified water extracts of the carrots are measured photometrically. Measurements were made in a 2-cm. cell with a 420 mμ color filter. From plots of the optical density *vs.* storage time, the numbers of days were determined for "low" and "medium" degrees of browning (taken as optical density increases of 0.120 and 0.360 unit, respectively). Discussion of the selection of the "low" and "medium" degrees of browning as a basis for comparison was given previously *(5)*.

RESULTS

Results are shown in Tables 1 and 2. Typical browning curves, illustrating the effect of heat damage during drying on the course of subsequent browning, are shown in Figure 1.

TABLE 2

Effect of heat damage during drying on browning during storage [a]

Blanching time	Heat damage during drying?	SO_2 (initial) MFB	H_2O MFB %	Initial optical density	Days for given degree of browning [b]	
					"Low"	"Medium"
(Min.)		*p.p.m.*				
2	Yes	0	6.4	.320	27 (27) [c]	82 (80)
2	No	0	6.5	.055	53 (53)	>150
2	Yes	850	6.6	.240	34 (35)	—
2	No	2650	6.2	.050	116 (109)	—
4	Yes	0	6.5	.310	31 (31)	95 (95)
4	No	0	6.6	.045	48 (49)	143 (145)
4	Yes	960	6.8	.190	38 (40)	—
4	No	2350	6.2	.060	97 (91)	—
8	Yes	0	6.8	.310	28 (30)	83 (88)
8	No	0	6.6	.110	53 (54)	>150
8	Yes	870	6.7	.260	40 (42)	—
8	No	2250	6.0	.090	126 (115)	—

[a] All lots were sprayed with water or sulfite solution after blanching.
[b] See Table 1, footnotes [d] and [e], respectively.
[c] See Table 1, footnote [e].

Effect of spray with water or sulfite solution. Leaching losses of 5 to 12% of weight of dry product resulted from the water or sulfite spray. The loss was approximately 3% higher for spray during blanching than for spray after blanching.

The water spray increased the time required for a given degree of browning by 15 to 35%. The sulfite spray increased the time for "low" degree of browning by 60 to 100% over the time for the corresponding water-sprayed samples.

Effect of soaking after blanching. Soaking the blanched carrots for 90 minutes in cool water caused leaching losses of 54 to 55% of weight of the dry product. Rate of browning was reduced to such an extent that "low" degree of browning did not occur in 150 days.

[1] The amount of heat damage during the latter drying schedule was about half that required to reach the "limit of palatability" previously selected *(6)*.

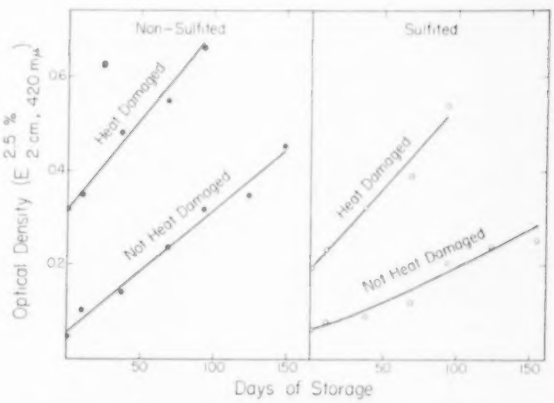

Figure 1. Effect of heat damage (see text) at end of drying on browning during storage at 100° F. (38° C.). Blanching time, 4 minutes; post-blanching spray with water or with sulfite solution; SO_2 content of the freshly dehydrated sulfited samples, 960 and 2360 p.p.m. for the damaged and undamaged samples, respectively.

Effect of steam blanching time. Blanching time had little effect on leaching loss, the observed losses being 1.5, 1.2, 3.4, and 3.6% for the lots blanched 0, 2, 4, and 8 minutes, respectively.

Variation in bleaching time from 2 to 8 minutes did not affect the rate of browning, but the unblanched samples browned somewhat more slowly than those blanched.

Carotene retention. Little difference in carotene retention was caused by the variations in processing conditions. During the early part of World War II, a number of workers observed an apparent increase in carotene content during drying. This was explained by Bailey and Dutton *(1)* of this Laboratory as due to loss of soluble solids during processing. In confirmation of their somewhat limited results, on an average the change in carotene content during processing and drying was negligible (3% loss).

Effect of heat damage at the end of drying. The nonsulfited samples that had been damaged by heat during drying browned 1.5 to 2.0 times as fast as the comparable nonscorched samples (Table 2). For the sulfited samples browning was about 3 times as fast in the heat-damaged samples as in those not damaged by heat. The sulfited, heat-damaged samples browned more rapidly than the nonsulfited samples which had not been damaged.

DISCUSSION

"Latent" or "incipient" heat damage. Commercial dehydrators have observed that severe heat treatment seems to produce changes ("latent heat damage") that may not be apparent in the freshly dried fruit or vegetable but are responsible for marked acceleration of browning during subsequent storage. This effect was observed by E. R. Stadtman and E. M. Mrak at the University of California, in work with comparable lots of peaches dehydrated under conditions of varying severity (private communication). However, for dehydrated vegetables no controlled experiments demonstrating this effect have been reported.

The faster rate of browning of the heat-damaged samples (Table 2) shows that latent heat damage can occur in dehydrated vegetables, since it was previously found that browning of nonsulfited dehydrated carrots pro-

ceeds at a constant rate *(6)* (see also Figure 1). Since these samples were rather badly heat damaged during dehydration, it cannot be predicted from these data whether or not the effect would have been detectable if heat damage had been maintained within commercial limits.[8]

Leaching losses during sulfite application. The observed leaching losses of 5 to 12% of weight of dry product would constitute a substantial economic loss to the processor. Losses could be diminished by the use of smaller volumes of sulfiting solution, as is common in commercial practice. Less sulfite solution, however, might reduce uniformity of sulfite distribution and result in greater susceptibility to browning.

Other methods of sulfite application should be investigated to determine whether higher yields and improved storage stability can be obtained, such as the "serial water blanching," with the sulfite in the blanching water, as practiced in England *(3)*, and direct-fire drying, which applies SO_2 as gas, utilizing the SO_2 present in the combustion gases when high sulfur content fuels are used.

SUMMARY AND CONCLUSIONS

Drench-spraying of half-diced carrots with water or with sulfite solution during or after steam blanching caused leaching losses of 5 to 12% of product weight (MFB). A 90-minute soaking after blanching, used to demonstrate the effect of extreme leaching conditions, caused leaching losses of 54 to 55%.

Leaching reduced the rate of browning during subsequent storage.

Time of steam blanching in the range of 2 to 8 minutes had little effect on leaching loss or on browning rate.

The total amount of carotene remained substantially unchanged during blanching, washing, and drying.

Heat damage in the latter stages of drying increased the rate of browning during subsequent storage.

[8] In work with dehydrated white potato to be reported subsequently an instance was found where relatively severe drying increased the rate of subsequent browning by approximately 75% over that in comparable material dried under mild conditions, although no scorching was evident in the freshly dehydrated materials.

Acknowledgment

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LITERATURE CITED

1. Bailey, G. F., and Dutton, H. J. Apparent increase in carotene of carrots during process of dehydration. *The Fruit Prod. J. and Am. Food Manufacturer*, **24** (5) 138, 142 and 155 (Jan., 1945).
2. Dutton, H. J., Bailey, G. F., and Kohake, E. Dehydrated spinach. Changes in color and pigments during processing and storage. *Ind. Eng. Chem.*, **35**, 1173-1177 (1943).
3. Great Britain—Ministry of Food. *Vegetable Dehydration*. 1946. His Majesty's Stationery Office, London.
4. Hendel, C. E., Bailey, G. F., and Taylor, D. H. Measurement of nonenzymatic browning of dehydrated vegetables during storage. *Food Technol.*, **4**, 344-347 (1950).
5. Legault, R. R., Hendel, C. E., Talburt, W. F., and Pool, M. F. Browning of dehydrated sulfited vegetables during storage. *Food Technol.*, **5**, 417-423 (1951).
6. Legault, R. R., Talburt, W. F., Mylne, A. M., and Bryan, L. A. Browning of dehydrated vegetables during storage. *Ind. Eng. Chem.*, **39**, 1294-1299 (1947).
7. Makower, B., Chastain, S. M., and Nielsen, E. Moisture determination in dehydrated vegetables; vacuum oven method. *Ind. Eng. Chem.*, **38**, 725-731 (1946).

The Improvement of the Flavor of Dehydrated Vegetables by the Addition of Vegetable Juice Concentrates[a]

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The feasibility of using vegetable juice concentrates to improve the flavor of dehydrated vegetables is explored. It is indicated that concentrates of juices from celery, onion and turnip can be used in conjunction with dehydrated vegetables and meat to increase palatability. It is shown that vegetable juice concentrates can be stored for comparatively long periods at 34° F. (+1.1° C.) without serious loss of desirable flavors.

Dehydrated vegetables lose flavor and develop off-flavors when stored at room or at higher temperatures. The present work was undertaken to determine whether or not it would be feasible to prepare vegetable juice concentrates, similar to that of the onion *(1)*, which would maintain satisfactory flavor quality during storage. If such concentrates retained desirable flavors after storage for reasonable periods of time, they could be used in combination with dehydrated vegetables and meat in the preparation of soups, stews, and other dishes served under Army field conditions.

[a] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 913.

PREPARATION OF CONCENTRATES

Concentrates from a number of vegetables—turnips, carrots, kale, cabbage, celery, and onions—were prepared from extracted juices.

Several methods were used for extracting juice. All vegetables were cleaned and trimmed by usual methods. Cabbage was sliced with a cabbage cutter and then milled in a Fitzpatrick comminuter without screens. The pulped material was pressed in a frame and cloth hydraulic press. Two lots were frozen at 18° F. (−7.78° C.) and later concentrated. A third lot was heated to 180° F. (82° C.), cooled immediately and then frozen. This treatment caused coagulation of the juice beginning at about 170° F. (77° C.) followed by precipitation and clarification.

Celery was blanched 2 minutes in flowing steam and then pressed. The pomace was milled and pressed again. Turnips were sliced into boiling water and cooked for 6 minutes. Carrots were treated similarly. Kale was steam blanched for one minute. The carrots and the kale were put through the Fitzpatrick mill before pressing. Vegetables and blanch water, when water was used for blanching, were pressed with the hydraulic press. The onions were peeled and blanched for 16 minutes at 180° F. (82° C.) cooled, and frozen immediately at 10° F. (—23.3° C.). They were thawed later, after which they were pressed. Another lot of onions was blanched in the same way, but was put through the Fitzpatrick mill and pressed without freezing. The yield was lower in the latter case; therefore, this procedure was no longer used. Each of the juices was cooled rapidly and frozen in 30 lb. tins at 18° F. (—7.78° C.). After freezing, concentrates were prepared from the various juices by freeze concentration *(3)*. Because of the low solids content of the juices, draining as well as centrifuging methods were used to separate liquid concentrate from ice. Several consecutive concentrations were necessary with these low solids liquids to obtain concentrates of 35° to 53° Brix. The concentrates were stored in 4- and 6-ounce bottles at 34° F. (1.1° C.) and at room temperature, usually about 70° F. (21.1° C.), with variation from 35° F. (+1.67° C.) to 100° F. (37.8° C.). It was found unnecessary to sterilize these concentrates for storage because they all seem to contain substances which are bactericidal in nature *(1, 5, 7, 8)*. The data involved in the preparation of the juice concentrates are presented in Table 1.

TABLE 1

Vegetable juice extraction and concentration

	Juice yield			Concentrate Yield		
	lbs.	° Brix	Percent recovery (based on vegetable)	Grams	° Brix	Percent recovery (based on juice)
Turnip	49	5.0	61	4805	46½	76½
Cabbage, raw	62	6.1	55	5350	52	85
Cabbage, raw	111	6.1	75			
Cabbage, heat treated	54	4.6	61	1890	51	84
Celery	75		80	1654	45	74
Onion	245	7.1	66	1219	52	82
Kale	72	3.4	76	1640	45	68½
Carrot	112	5.3	75	4545	50½	86½

In order to have a supply of dehydrated materials for flavor evaluation studies, carrots, turnips, potatoes, and beef were prepared as follows: The carrots were peeled in an abrasive peeler, diced into ¼" cubes, blanched for 3 minutes in flowing steam, cooled, and dehydrated. Turnips were peeled and diced in the same manner, but were blanched for 4 minutes in flowing steam, and then dehydrated. Potatoes were peeled and diced, blanched for 3 minutes in flowing steam, and dehydrated. All vegetables were dehydrated in moving air for 24 hours at 150° F. (66° C.) in a pilot plant commercial type batch drier. Lean beef was cut into 1½" cubes and cooked in an autoclave at 15 lbs. pressure for 15 minutes. It was then ground in a food chopper and dehydrated for 10 hours at 150° F. (66° C.) in the dehydrator. Each of the products obtained was placed in 2 screw capped glass jars; one was stored at room temperature, and the other at 0° F. (—17.8° C.). The products were stored at 0° F. (—17.8° C.) to give one lot of each dehydrated product the best possible protection against deterioration.

SENSORY FLAVOR TESTS

The triangle taste test procedure was used to determine the effect of storage at 34° F. (+1.1° C.) and room temperature at time intervals up to 11 months on the flavor of vegetable juice concentrates. Taste tests were run also on the lots stored for approximately 3 years.

Formulas and rehydration procedures. The following formulas for soup and stew were considered satisfactory. In addition to the juice concentrates, dehydrated carrots, turnips, meat, and in the case of the stew, potatoes were used.

Soup	Weight in grams
Celery concentrate	10
Onion concentrate	7
Turnip concentrate	6.5
Salt	8
Dehydrated carrots	8
Dehydrated turnips	8
Dehydrated beef	8
Water	800 mls.

Vegetable Stew	Weight in grams
Celery concentrate	10
Onion concentrate	5
Turnip concentrate	6.5
Beef extract	4
Dehydrated carrots	10
Dehydrated turnips	15
Dehydrated potatoes	12
Dehydrated beef	12
Water	400 mls.

For each formula vegetables and meat were soaked in water, for ½ hr. to rehydrate, slowly boiled for a sufficient length of time to give a satisfactory product, with water replenished as needed. In both soups and stews, the concentrated vegetable juices were added to dehydrated products at the end of the cooking period in order to prevent an excessive loss of volatile flavors.

The above test procedure was repeated in comparing the vegetable concentrates stored for 3 years at 34° F. (+1.11° C.) with those stored at room temperature for this same length of time.

Dehydrated carrots stored for 3 years at room temperature and at 34° F. (+1.11° C.) were available. However, only dehydrated turnips stored in the cold room and dehydrated potatoes held for one year at room temperature were available. The dehydrated meat had been used in previous tests and none was left for this final test. A beef bouillon cube was used to replace the meat; the same turnips and potatoes were used in both formulas comparing the room and cold temperature storage concentrates.

Monochromatic light used in the earlier tests would not cover up the difference in color between the samples which had been prepared from concentrates held at room temperature and cold room storage for 3 years. Because of this the triangle test was not used for these last tests.

Results. Onion, celery and turnip juice concentrates were found to maintain a satisfactory flavor when stored at room temperature for reasonable periods of time but cabbage concentrate was somewhat adversely affected. Concentrated kale, carrot, rutabaga, and unheated cabbage juices developed undesirable flavors when stored at room temperature and gave undesirably flavored products when used in soups and stews. Onion, celery, and turnip concentrates only, therefore, were considered for use. All the concentrates studied kept well when stored at 34° F. (+1.1° C.).

The soups and stews prepared with the dehydrated vegetables without the addition of the vegetable juice concentrates were not too good, but were materially improved by the addition of the concentrates. In the tests soups and stews containing concentrates which had been stored at 34° F. (+1.1° C.) for 10 months and the solid vegetables and meat stored at 0° F. (—17.8° C.) and other lots with these ingredients stored at room temperature, and scored on a 10-point scale in which 10 was the highest rating, gave the following results. Soup rated 7.0 when made from ingredients which had been stored at low temperature and 6.0 when made from ingredients which had been stored at room temperature. For stews the corresponding figures were 7.9 and 7.3. Stew was prepared from concentrates which had been held in storage for three years at 34° F. (+1.1° C.) and was examined by the taste panel. The average score was 7.4 on a 10 point scale. The average score for the stew made with concentrates held at room temperature for the same period of time was 4.6. The average scores obtained from the soups made from the same materials was 7.0 and 4.9 respectively. There was, of

course a significant difference between the soup and stew made from room and cold storage materials. However, the room-temperature stored materials yielded not too objectionable soups and stews after 3 years' storage. The soup and stew made from dehydrated vegetables would have had very little flavor without the addition of vegetable concentrates.

CHEMICAL CHANGES DURING STORAGE

After storage for one year the vegetable concentrates were analyzed for volatile sulfur[b] according to the method of Platenius *(6)*. The results, Table 2, show that at the higher storage temperature significantly lower amounts of volatile sulfur compounds were found to be present when contrasted with the volatile sulfur compounds found in corresponding samples stored at 34° F. (1.1° C.). However, these differences were not great enough to make the products unsatisfactory for use. In the cases of turnip and onion concentrates, the lower values in volatile sulfur content of those lots stored at room temperature did not appear to affect appreciably the final quality of the soup or stew when these concentrates were used in the preparation of them.

TABLE 2

Volatile sulfur contents of vegetable concentrates after storage for one year

Vegetable	Storage temp.	Volatile sulfur per 100 grams
	° F.	mg.
Turnip	34°	10.1
Turnip	room[a]	8.1
Onion	34°	10.2
Onion	room[a]	5.8
Cabbage, heat treated	34°	12.1
Cabbage, heat treated	room[a]	9.0
Cabbage, raw	34°	12.4
Cabbage, raw	room[a]	9.2

[a] Room temperature was decidedly variable. Much of the time it was between 70° F. (21.1° C.) and 80° F. (26.7° C.). The extremes, however, were from about 35° F. (−1.67° C.) to 100° F. (37.8° C.).

Darkening of the product is indicative of deterioration of the material. Color readings (Table 3) were taken at 420 mμ using a Beckman Quartz Spectrophotometer. The concentrates prepared from onion, celery, turnip, rutabaga, carrot, cabbage, and kale were reasonably optically stable at 34° F. (+1.1° C.) for 3 years. Celery juice concentrate had undergone little change during storage for 10 months at room temperature insofar as optical density is concerned. However, a most marked change occurred after 36 months at room temperature. The onion juice concentrate had darkened considerably as shown by the results obtained from the sample stored at room temperature as contrasted with that obtained from the sample stored at 34° F. (+1.1° C.). Results are not available for turnip juice concentrates after 10 months of storage, but the data taken after 2 and 3 years' storage show a substantial increase in the optical density of the sample stored at room temperature when contrasted with the original and with that stored at 34° F. (+1.1° C.).

The centrifuged solutions were clear or nearly so. The results indicate that the greater change in the samples stored at room temperature came about as the result of formation of soluble color substances, rather than precipitated material. Working with fruit juices, Pederson, Beattie, Stotz *(3)*, found that color changes precede the formation of insoluble materials. One might suggest that if this is the case in vegetables, the changes that occurred in room-temperature stored samples were not of major importance. The products were usable, although not highly desirable, after the long storage period.

TABLE 3

Changes in optical density of vegetable juice concentrates during storage

Vegetable	Storage		Optical density at 420 mμ	
	Temperature	Time in months	Not centrifuged	Centrifuged[d]
Celery (Pascal)		0	12.2	
	Room	3½	11.2	
	Room	11		10.2
	Room	40	55.3	50.7
	34° F.	3½	11.8	
	34° F.	11	13.3	
	34° F.	40	12.3	6.6
Onion (yellow globe var.)		0	4.5	
	Room	4	32.6	
		11	45.3	
		41	129.0	115.0
	34° F.	4	8.6	
		11	11.1	
		41	32.9	19.0
White Turnip		0	4.7	2.7
	Room	24	24.8	24.2
		30	40.5	38.9
	34° F.	24	6.8	4.6
		30	8.7	5.8
Rutabaga		0	4.2	
	Room	7	9.5	7.7
		37	33.2	30.5
	34° F.	7	5.4	1.7
		37	5.4	4.3
Carrot (Chantenay)		0	11.6	5.1
	Room	30	30.0	23.3
	34° F.	30	12.3	4.4
Cabbage blanched		0	5.2	2.5
	Room	30	77.5	73.5
	34° F.	30	8.7	5.3
Kale		0	22.4	13.8
	Room	30	69.2[e]	53.9
	34° F.	30	32.6	25.1

[d] At approximately 1900 r.p.m. for 15 minutes. (Clay-Adams Safety Head Centrifuge—CT 1000).

[e] Chunks of precipitate were observed in the room temperature-stored kale concentrate.

SUMMARY

Concentrates of juices from celery, onion, and turnip were prepared by freezing concentration. These were used in conjunction with dehydrated vegetables and meat to prepare more palatable dishes than could be made with dehydrated materials used alone. Other vegetable juices were prepared also, but those tried did not hold up well enough in storage to be of value.

Volatile sulfur and optical density determinations which were made to follow changes during storage showed a close relationship between changes in flavor and color.

It is clear that vegetable juice concentrates can be stored for comparatively long periods of time at 34° F. (+1.1° C.).

[b] The authors wish to express their appreciation to Miss Joanne Whitcombe for technical assistance in this work.

LITERATURE CITED

1. Fuller, J. E., and Higgins, E. R. Onion juice and bacterial growth. *Food Research*, **5**, 503-7 (1940).
2. Lee, F. A., Beattie, H. G., and Pederson, C. S. Onion juice concentrate prepared by freezing concentration. *Fruit Products J.*, **27**, 141, 153 (1948).
3. Pederson, C. S., and Beattie, H. G. Concentration of fruit juices by freezing. New York Agr. Exp. Sta. *Bull.*, **727**, 27 pp. (1947).
4. Pederson, C. S., Beattie, H. G., and Stotz, E. H. Deterioration of processed fruit juices. New York Agr. Exp. Sta. *Bull.*, **728**, 32 pp. (1947).
5. Pederson, C. S., and Fisher, P. The bactericidal action of cabbage and other vegetable juices. New York Agr. Exp. Sta. *Bull.*, **273**, 32 pp. (1944).
6. Platenius, H. A method for estimating the volatile sulfur content and pungency in onions. *J. Agr. Research*, **51**, 847 (1935).
7. Toropev, I., and Kamnev, I. Certain data on the nature of phytoncides. I. *Compt. Rend. Acad. Sci. U.R.S.S.*, **51**, 373-5 (1946); *Chem. Abs.*, **40**, 6676 (1946).
8. Walker, J. C., Lindegren, C. C., and Bachmann, Freda. Further studies on toxicity of juice extracted from succulent onion scales. *J. Agr. Research*, **30**, 175-87 (1925).

Studies on Meat. IV. The Use of Antibiotics in Preservation of Fresh Beef[a,b]

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A study was made to determine the effect of various antibiotics in preserving ground beef and against a wide variety of organisms isolated from beef tissue. In addition assays were conducted to determine residue of aureomycin in ground beef during various periods of storage at 10° C. Some evidence is presented indicating usefulness of antibiotics in beef preservation.

The wide antibacterial activity of antibiotics has directed studies toward the possibility of using these substances in food preservation.[c] Emphasis to date has been placed on the use of an antibiotic such as subtilin combined with mild heat to preserve canned foods. Some studies have appeared recently from federal laboratories and other sources *(1, 2, 9, 10)*. Other antibiotics have been studied with varied results and generally promising studies have been lacking. Cameron *(3)* has evaluated these data to date. Just recently Tarr, Southcott and Bissett *(8)* reported studies on the use of antibiotics in several flesh foods, and their results agree quite closely in some respects with those to be reported in this paper.

Since much of the previous work has been confined to addition of antibiotics to heat processed foods it was thought wise to determine the effect of certain antibiotics on a fresh food. Beef would seem to be an ideal food in which to test the success of antibiotics in food preservation. Beef has a relatively high spoilage rate where proper refrigeration is lacking; since it is a highly suitable medium for microbial growth the efficacy of the antibiotics under study could be accurately determined. Some work in this area has been reported by Jensen *(7)* in which he isolated antibacterial substances from plants and added them to brine in which meat was being cured. However, the study to be reported here and in subsequent work is to be confined to fresh beef.

EXPERIMENTAL PROCEDURES

I. The first experimental study consisted of screening of better known antibiotics in fresh ground beef. The following 6 antibiotics were selected on the basis of their availability and wide antibacterial ranges, penicillin, bacitracin, streptomycin, aureomycin, chloromycetin and terramycin. Original stock solutions of these compounds were made to concentration of 20γ/ml. and lesser concentrations diluted from this stock. The meat used in these studies was procured from the University Meats Laboratory as chuck and was ground prior to each experiment. Four concentrations of each antibiotic were studied. Final concentrations of antibiotic to ground beef was in the four samples 2 p.p.m., 1.5 p.p.m., 1 p.p.m., and 0.5 p.p.m.

The antibiotic solution was added to 100 g. of beef in a 600 ml. beaker, then the solution was stirred into the ground beef with a glass rod for 30 seconds. At the end of this period no solution was discernable as it was well absorbed by the ground beef. Controls were treated in like manner with 1 ml. of distilled H_2O substituted for the antibiotics. Following this procedure the meat was placed in a 350 ml. specimen jar, covered with a 4-inch watch glass and placed in the refrigerator at 10° C.

The meat samples were observed daily for color and noted as to odor and consistency. Samples were taken after the first 3 days of 10° C. incubation and thereafter every 2 days. Counting procedure was based on that of Elford *(7)* with the following modification: the media of choice was North Gelatin Agar since experience in this laboratory has shown this medium to be highly effective in supporting growth of the microflora of meat.

II. There were available in this laboratory stock cultures of 92 distinct organisms representing 12 genera which had been isolated from the lymph nodes, bone marrow and muscle tissue of 23 beef cattle. Antibiotics found effective in the ground beef were tested against these inherent flora of beef. Bacto sensitivity discs were used throughout and susceptibility or resistency of organisms determined by zones of inhibition at the various concentrations. Plates were incubated 24 hours at optimum temperature and oxygen conditions.

III. Of prime importance in this study is the residual antibiotic left in the ground beef during various storage times. Consequently a standard antibiotic assay for body fluids was adapted to beef samples. The assay selected was that reported for aureomycin by Dornbush and Pelcak *(5)*. This assay is a tube dilution method and requires no sterile precautions because of the extremely short incubation time.

The beef samples had to be treated to extract the aureomycin from the meat and obtain it into a clear solution that showed no turbidity since opaque solutions would interfere in the turbidimetric assay employed. In the first step a sample of beef which had aureomycin incorporated in the manner reported was triturated. A 10 g. ground beef sample was ground with 1 g. of sea sand in 25 ml. H_2O in a mortar. The resulting slurry was filtered through several thicknesses of No. 1 filter paper in a Buchner funnel and washed with distilled water in amounts resulting in an ultimate ten-fold dilution. If only a slight amount of antibiotic was expected in the sample, correspondingly smaller final dilution of the sample was made. At this point the filtrate usually contained some particles of beef which were removed by refiltration through one thickness of filter paper. This filtrate was handled as any body fluid, urine, blood, etc. Then the procedure of Dornbush and Pelcak *(5)* was followed with the exception that the penicillin assay broth was used in place of nutrient broth *(4)*. Dilutions were seeded with 1.5 ml. of a 1:100 dilution of an 18-hour broth culture of Bacillus No. 5 (a strain of *Bacillus cereus var. mycoides*). Readings were made after 4 hours' incubation at 37° C., and the highest dilution of meat filtrate inhibiting growth of the test organism was determined and compared with the inhibiting dilution of known concentrations of aureomycin. In our hands, the test was sufficiently sensitive to detect concentrations of 0.125 mg. of aureomycin per g. of meat. Assays of 12 different ground beef samples originally containing 2 p.p.m. aureomycin were made in this manner.

[a] A portion of this paper was read at the 52nd Annual meeting of the Society of American Bacteriologists in Boston, Mass., April 29, 1952.

[b] Published with the permission of the Associate Director, Ohio Agricultural Experiment Station as Journal Article 46-52.

[c] The physiological effects of various antibiotics, if used in foods, has not been established. Practical use of these agents in foods is not permitted at the present time.

RESULTS AND DISCUSSION

I. Ground beef samples containing penicillin, bacitracin and streptomycin were ineffective, spoilage occurring after 5 days incubation at 10° C. along with the control. Chloromycetin, aureomycin and terramycin slowed the rate of spoilage and increased the storage life of the beef to 9 days. Tables 1 and 2 indicate results for the antibiotics in each group.

TABLE 1
Average bacterial counts in millions per gram of beef

Antibiotic	Days storage 10° C.	Concentration of antibiotic				Control 0.0 p.p.m.
		2 p.p.m.	1.5 p.p.m.	1.0 p.p.m.	0.5 p.p.m.	
Streptomycin 1+	0	0.2	0.2	0.2	0.2	0.2
	3	9.0	9.5	10.0	9.0	9.5
	5	putrid[a]	putrid	putrid	putrid	putrid
Penicillin	0	0.1	0.1	0.1	0.1	0.1
	3	3.0	3.0	3.0	4.0	4.0
	5	putrid	putrid	putrid	putrid	putrid
Bacitracin 4.2 μ/mg.	0	0.2	0.2	0.2	0.2	0.2
	3	19.6	1.3	1.2	2.7	3.0
	5	putrid	putrid	putrid	putrid	putrid

[a] Putrefaction determined by odor and color.

TABLE 2
Average bacterial counts in millions per gram of ground beef

Antibiotic	Days storage 10° C.	Concentration of antibiotic				Control 0.0 p.p.m.
		2 p.p.m.	1.5 p.p.m.	1.0 p.p.m.	0.5 p.p.m.	
Aureomycin	0	0.2	0.2	0.2	0.2	0.2
	3	0.3	0.3	0.5	0.5	100.0
	5	0.99	4.8	10.1	39.0	putrid[a]
	7	5.0	10.0	30.0	75.0	putrid
	9	8.0	30.0	70.0	100.0	putrid
Terramycin	0	0.2	0.2	0.2	0.2	0.2
	3	0.6	0.3	1.8	17.0	215.0
	5	0.7	83	putrid	putrid	putrid
	7	24.0	putrid	putrid	putrid	putrid
	9	55.0	putrid	putrid	putrid	putrid
Chloromycetin	0	0.2	0.2	0.2	0.2	0.2
	3	0.55	0.45	0.5	5.0	4.0
	5	4.0	4.5	7.0	7.0	putrid
	7	7.0	9.0	12.0	14.0	putrid
	9	7.5	10.0	12.5	15.0	putrid

[a] Putrefaction determined by odor and color.

It would seem that the organisms responsible for spoilage of ground beef belong to a wide variety of genera and only these antibiotics with the widest spectrum influence the spoilage rate.

II. The 3 antibiotics, chloromycetin, terramycin and aureomycin which were found effective in the ground beef gave similar results against the organisms isolated earlier from the beef tissues. Table 3 reveals the high antibacterial activity of these compounds against the pure cultures from lymph nodes, bone marrow and muscle tissue. Selection of an antibiotic of choice for further studies on beef preservation would then have to be based upon such criteria as physical, chemical and economic properties. One of the most important factors is the amount of antibiotic residue found in the beef at the time of retailing.

III. Of the 12 samples assayed for aureomycin residues, nine showed residues of 2.0, 1.0, 0.125 and 0.0 mg. per g. of beef at 24, 48, 72 and 96 hours respectively. The remaining 3 samples showed 1.0, 0.125, 0.0 and 0.0

TABLE 3
Effect of antibiotics upon the organisms isolated from beef tissues

Name of genus	No. of organisms per genus	No. of organisms inhibited by aureomycin	No. of organisms inhibited by chloromycetin	No. of organisms inhibited by terramycin	No. of organisms unaffected
Aerobacter	1	0	0	0	1
Alcaligenes	6	4	6	4	0
Clostridium	3	3	3	3	0
Corynebacterium	2	2	2	2	0
Escherichia	18	15	12	14	3
Flavobacterium	5	5	4	4	0
Intermediate coliforms	10	10	9	10	0
Micrococcus	2	2	2	2	0
Proteus	2	0	0	0	2
Pseudomonas	9	9	9	9	0
Serratia	2	2	2	2	0
Streptococcus	32	29	25	27	3
Totals	92	81	74	77	9

micrograms aureomycin residue per gram of beef at similar storage times. It would appear that the antibiotic begins to disappear within 24 hours, and after 72 hours is no longer detectable by the available assay method. This suggests that the action of the antibiotic may be bacteriostatic, and when it disappears the organisms begin to grow and ultimately a delayed spoilage occurs.

SUMMARY

Six antibiotics, penicillin, streptomycin, bacitracin, chloromycetin, terramycin and aureomycin, were tested for their preservative action in fresh ground beef.

Chloromycetin, terramycin and aureomycin successfully lengthened keeping quality of the beef and also showed a high activity against pure cultures of microflora isolated from deep tissues of beef.

Assay for aureomycin residue in stored beef showed no detectable antibiotic after 72 hours.

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LITERATURE CITED

1. Anderson, A. A., and Michener, H. D. Preservation of foods with antibiotics. I. The complementary action of subtilin and mild heat. *Food Technol.*, **4**, 188 (1950).
2. Anderson, A. A., and Michener, H. D. Effect of subtilin on bacterial spores. *Bact. Proc.*, 28 (1950).
3. Cameron, E. J. Use of antibiotics in preserving foods. *Proc. 3rd Conf. Research Am. Meat Inst.*, 32 (1951).
4. Dornbush, A. C. (Personal communication, 1952.)
5. Dornbush, A. C., and Pelcak, E. J. The determination of aureomycin in serum and other body fluids. *N. Y. Acad. Sci.*, **51**, 218 (1948).
6. Elford, W. C. Bacterial limitations in ground fresh meat. *Am. J. Pub. Health*, 1204, **26** (1936).
7. Jensen, L. B., and Hess, W. R. Meat curing pickle solution containing antibiotics. U. S. Patents 2,550,253-2,550,269 (1951).
8. Tarr, H. L. A., Southcott, B. A., and Bissett, H. M. Experimental preservation of flesh foods with antibiotics. *Food Technol.*, **9**, 363 (1952).
9. U.S.D.A. Agr. Research Administration. Antibiotics tested for preserving food (Release, U.S.D.A. 2765-49), Dec. 29, 1949.
10. U.S.D.A. Agr. Research Administration. Research shows how antibiotic kills food poisoning organisms (Release, U.S.D.A. 1216), May 17, 1950.

Some Observations on the pH of Pork Under Various Conditions[a]

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Additional data on the pH of pork under various conditions are reported. The pH of hams while on the carcass and when not in contact with the carcass, the pH of Psoas major immediately after slaughter, the effects of repeated freezing and thawing on the pH of loin roasts (Longissimus dorsi) and the effect of repeated freezing and thawing of pork sausage under 3 types of packaging are the objects of study.

The pH of meat is a useful key to understanding the complicated events which take place in the carcass and under many circumstances the scale of change in pH is a far more helpful guide than the scale of time. The determination of pH presents little more difficulty than the determination of temperature and the results can be applied with profit in determining the influence of various treatments of slaughterhouse animals on the properties of meat. It is known, for example, that adjustment of the pH of meat affects certain of its properties, especially the extent to which frozen meat drips after thawing *(2, 6)*. In unfrozen meat, the best keeping quality is shown by meat having a low pH. Ingram *(8)*, working with controlled hams, found that pH had a marked effect on the growth of bacteria. Watt *(14)* determined that the pH of freezer-stored pork sausage influences the rate of oxidation of fat; i.e., rancidity development is lower when the pH is higher.

REVIEW OF LITERATURE

The major factor affecting pH in meat is the formation of lactic acid from glycogen in the tissue. Although this reaction requires no more than the addition of water to glycogen, $(C_6H_{10}O_5)n+nH_2O \longrightarrow 2nC_3H_6O_3$, between the initial and final states an extremely complicated series of transformations is interposed.

The precise pH of the muscle immediately prior to cessation of the circulation depends on the recent history of muscular activity *(2)*. Evidence indicates the pH of the live tissue with a minimum amount of lactic acid to be in the neighborhood of 7.4 *(13)*. A resting muscle has a neutral reaction and normally contains a considerable amount of glycogen. After death the pH decreases with the production of lactic acid. According to Bate-Smith *(2)*, there are 2 factors which have the effect of decreasing the fall of pH, the liberation of carbon dioxide from bicarbonate and the breakdown of creative phosphate.

Change in pH has at various times been regarded as the actual cause of *rigor mortis*. But the idea that *rigor mortis* is due to production of lactic acid is negated by the fact that *rigor mortis* sets in at times without any change in acidity whatsoever. Nevertheless, it is interesting that when sufficient lactic acid is produced, *rigor mortis* always sets in when the muscle reaches a certain pH *(2)*.

As mentioned, the amount of glycogen in the muscle tissue is dependent upon the muscular activity prior to slaughter. Callow *(4)*, found that carcasses from fatigued pigs have muscular tissue with a higher pH than those from well-rested animals. Moreover, resting before slaughter progressively diminishes the after-effects of fatigue, and yields muscular tissue with a progressively lower pH.

The results of fatigue and resting can best be explained in terms of physiological changes of muscle following death. The pH of muscle represents a balance between (a) the buffering power of a group of substances which alone give a pH near neutrality and (b) acidic substances of which the most important is lactic acid. The amount of lactic acid in a muscle varies greatly. In life, lactic acid formed from muscular glycogen during exercise is removed by way of the blood. After death, the glycogen reserve is gradually broken down to lactic acid during *rigor mortis*. Because of the cessation of the circulation, however, the acid accumulates in the muscle. If the muscle is fatigued shortly before death its glycogen reserve is depleted; therefore, less lactic acid formation is possible during *rigor mortis* and in consequence the flesh is ultimately less acid. If the muscle is not fatigued, there will be a full reserve of glycogen and a greater amount of acid can be formed—resulting in a lower pH.

Bate-Smith *(1)* found that if animals are not fed during the rest period, replenishment of the glycogen in the muscle takes place very slowly from the liver. If the animals are fed, the glycogen is supplied from the blood and the replacement is more rapid and the supply from the liver is not needed. Replenishment is particularly rapid if sugar or a high sugar content feed is used.

If the muscles have been completely inert and well-supplied with oxygen for a relatively long period before death, say 16-24 hours, metabolism will be completely aerobic and the lactic acid content will be very low.

The immediate effect of exercise on a muscle is the decrease in its glycogen content. However, if the work is light, and nutrients are available, the glycogen is replenished as the work proceeds. In a well-nourished animal, recovery of glycogen after exercise is usually rapid.

Bate-Smith *(1)* is of the opinion that an animal's struggling on the slaughtering floor should be reduced to a minimum. Loss of glycogen from the muscle is particularly heavy during exertion of short duration; hence, while the animal is yet alive and struggling the glycogen passes directly into the blood and, after slaughter, is lost during bleeding.

Callow *(5)* found that feeding was necessary to increase muscle glycogen after exercise. In his experiments, hogs were shipped one mile by truck and then walked a quarter of a mile before slaughter. The ultimate pH in the Psoas major of a group, rested overnight but not fed, averaged 5.80 as against 5.79 for the unrested; whereas a group which was both rested and fed had an average pH of 5.58 as against 5.87 for the unrested control groups. Previous work by Callow *(3)* indicates "'resting' must, in fact, be *resting* in order to be effective." Pigs tend to fight among themselves when strange groups are mixed in pens; under these circumstances no recovery of glycogen takes place.

A second example given by Callow *(4)* concerns a group of pigs which although rested after their journey for periods from 2½ to 17 hours, were walked one-half mile to the slaughter house. They had average ultimate pH values of 6.00-6.18. Similar groups carried the short distance by truck had average pH values of 5.75-5.83. These differences appear surprisingly large for such apparently small differences in handling.

Kidd *(9)* has reported that the length of the delay before the onset of rigor is determined by (a) the pH of the muscle at the moment of death and (b) the glycogen content of the muscle. Since the activity of the animal just before death affects both these factors, it is now confirmed that this activity is the most important single factor influencing the post mortem behavior of the muscles.

With recent improvements in the glass electrodes, changes in the pH of muscle can now be followed by means of a fine spear-shaped electrode. The value recorded is, of course, that of the fluid in the intercellular spaces which in the living animal must differ from that of the cell contents *(7)*.

[a] Contribution No. 187 from the Department of Animal Husbandry, Kansas State Experimental Station.

However, at some stage in dying, muscle equilibrium is reached between these two phases. In life, the membranes have the ability to repel the diffusion of ions but upon death there is a free diffusion of ions through the previously impermeable membranes which results in a rapid equalization of pH throughout the tissue. This was shown by Bate-Smith *(1)* where the value recorded by the spear electrode was identical with that of the minced and ground tissue.

Madsen *(10)* using feeds with added sugar two days before slaughter and feeds with normal amounts of sugar or no sugar, found that the average pH of the Psoas major was 5.50 in the animals given sugar. In animals held off feed completely it was 5.87. Particularly important was the keeping quality of the pork of the two different groups. The test showed that the appearance of the fresh pork was influenced by the addition of sugar to the meat. If the pork from the animals fed sugar was stored in a cool and dry place, it had a more satisfactory surface condition than the pork from the animals held off feed. There was also a substantial difference in the odor of the fresh pork. The odor of the pork from the unfed pigs became rank, whereas that from the sugar fed pigs was pleasantly sweet.

In salted pork, the surface of the cured sides from the unfed group were in a slimy condition 11 days after removal from the curing tank, while those of the fed group took 21 days to reach the same condition. The surface condition was accompanied by a considerably better surface color which gave it a fresher and more appetizing appearance. Thus the pH of the mass of the muscular tissue may affect the microbiological spoilage, not only in the interior as Callow showed, but also on the surface of the carcass.

Methods in use prior to 1930 for determining pH resulted in a most extraordinary variation in the recorded values. Ritchie *(11)* quotes values from the literature up to 10.0 for the pH of muscle. Since then the use of the glass electrode has become widespread and the quoted values can be regarded as more reliable.

Several authors have observed variation between different muscles of the same animal and the same muscle of different animals. However, they agree that there is much less variation in beef than in pork. Callow *(4, 5)* showed that muscles vary in their sensitivity to fatigue—for example, the pH for the Psoas major was 5.72 while a pH of 5.48 was obtained for the *Longissimus dorsi*. Callow *(5)* suggests that the proximity to bone may explain this variation. Neutralization of lactic acid by calcium carbonate in the bone is a factor that could cause a rise in pH. Bate-Smith *(2)* believes it more likely that the variation in ratio of connective tissue to muscle tissue is the determining factor. As the muscle narrows towards its insertion the ratio decreases. Therefore, the production of lactic acid in the tissue decreases and a fall in the pH results. The same author *(2)* believes freezing has little or no effect on pH.

METHODS AND PROCEDURE

The present study was undertaken to secure additional information on effects of pH on pork under various conditions. Determinations were made as follows:

(a) On hams: by inserting the electrode directly into the hams while on the carcass.
(b) On hams: by removing a portion of the ham and determining the pH while not in contact with the carcass.
(c) On Psoas major: by removing Psoas major from the carcass immediately after slaughter.
(d) On *Longissimus dorsi:* by observing the effects of repeated freezing and thawing on the pH of loin roasts.
(e) On pork sausage: by observing the effect on pH of repeated freezing and thawing of pork sausage under three types of packaging.

The equipment consisted essentially of a Beckman Model H-2 glass electrode pH meter, sensitive to 0.03 pH unit. With this pH meter, calibrations were only to 0.1 units; therefore, the combined error of the pH meter and the interpretation of the operator brought the accuracy generally obtained to 0.1 units.

In the first work with this meter it was not found practical to work in the cooler, due to inaccuracy under those conditions. Therefore, all readings in this study were made at room temperature. The meat used was kept in the cooler until the equipment was ready and then taken out. Under these conditions the reading appeared to be accurate or at least could be duplicated.

The question of the accuracy of the readings made by inserting the electrodes directly into the muscle tissue was considered. On the basis of a statement by Bate-Smith *(2)* that the fluids in the intercellular spaces have a different pH than the cell contents in life but that soon after death pH equalizes throughout the tissue and after comparing the readings secured by inserting the electrodes directly into the muscle tissue with readings made of minced tissue distributed into distilled water the accuracy of the method seemed to be confirmed. The similarity of the readings procured by the 2 methods described seemed to leave no doubt that determining pH values by inserting the electrodes directly into the muscle tissue is a valid procedure. Therefore, all observations were made by this method.

The determinations in the hams were made beginning shortly after slaughter and continued as long as possible under the conditions present. In many cases the carcasses were cut and packaged after a 48-hour chill, making further readings impossible. These determinations were made by inserting the electrodes into the hams, posterior to the aitch bone, with care being taken to avoid contact with bone.

In the second group of observations, made on slices removed from the ham, a portion of each ham was removed, and a series of determinations was run to study the effect of tissue removed from the carcass.

The Psoas major was removed from the carcass immediately following slaughter and pH readings were made for a period of 48 hours after slaughter.

Pork loins were boned and cut into 3 roasts of approximately equal lengths. All readings were made from the posterior end. Each reading was made by removing a chop or slice approximately ¾ of an inch thick from the posterior end of a roast; this slice was used for the pH determination. The remainder was frozen on a plate freezer at —10° F. The package was then removed and placed in a 34°-36° F. cooler for a period of 24 hours, at which time another sample was taken from which the pH determination was made. This was continued until the entire roast was used.

The pork sausage used in this experiment was made to a ratio of approximately 25% fat and 75% lean, and seasoned with 1 pound of salt, 2 ounces of pepper, and 2 ounces of sage per 50 pounds of meat. The trimmings were ground first through a ¾ inch plate followed by a grinding through ⅜ inch plate and then a ⅛ inch plate. The sausage was cooled in a 34°-36° F. cooler for 24 hours and packaged as follows:

(a) 2-pound package wrapped in cellophane with "Tite."[b]
(b) 2-pound package wrapped in "Tite."
(c) package 12 inches by 12 inches by two inches wrapped in "Tite."

In all 3 cases the confectioners' type of wrapping was used.

DISCUSSION

Four of the pH readings made by inserting the electrodes directly into the ham are graphically illustrated in Figures 1, 2, 3, and 4. Figure 1 illustrates graphically the pH curve that would be expected if the breakdown from glycogen to lactic acid was the determining factor and no other force was present to affect the pH.

Figure 2 illustrates a slight increase in the pH which appeared in many cases approximately 48 hours after slaughter. Figure 3 indicates there is a rise in the pH following slaughter which usually terminates approximately 6 hours after slaughter. This increase was found to appear in many, though not in all, hams. Figure 4 illustrates both the rise in pH at approximately 6 hours

[b] "Tite" is a commercial glassine laminated paper for wrapping frozen food.

THE pH DETERMINATIONS OF HAMS MADE BY DIRECT INSERTION OF ELECTRODES

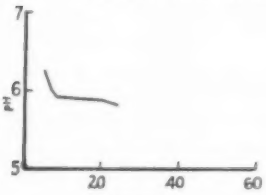

Figure 1
Hours after slaughter

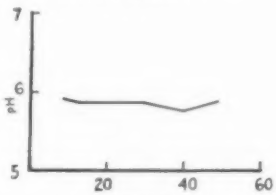

Figure 2
Hours after slaughter

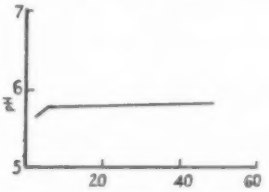

Figure 3
Hours after slaughter

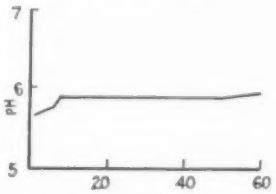

Figure 4
Hours after slaughter

and the rise which appears at approximately 48 hours after slaughter.

The variation of pH, by inserting the electrodes directly into the ham muscle was found to range from 4.8-6.5.

Four samples of various pH readings of the Psoas major, starting shortly after death and continuing for 48 hours, are graphically illustrated in Figures 5, 6, 7 and 8.

In the Psoas major, as in the ham muscle, it was found there existed certain characteristics. The rise in pH terminating at approximately 6 hours after death and the rise at approximately 48 hours following slaughter were both observed in many cases.

During the past year, Kansas State College conducted an experiment in which eight hogs were shipped 36 miles by truck. After this, the hogs were treated as follows; 2 hogs (Nos. 35 and 37) were given feed and water, 2 hogs (Nos. 34 and 36) were rested 2 hours and given only water, 2 hogs (Nos. 38 and 40) rested 16 hours and were given feed and water. Figures 5, 6, 7 and 8 graphically illustrate the pH of these hogs under these 4 conditions. The pH curve of Hog No. 36 which was given 2 hours rest and water only is shown in Figure 5. There was a very slight increase in the pH of the Psoas major muscle. Since the increase was less than 0.1 units, its significance is not certain. There may be very little if any change—due to the absence of glycogen in the muscle at time of slaughter. This is in accordance with Callow *(1, 5)*.

Figure 6 illustrates hog No. 35, which was given 2 hours rest with feed and water. There was a slight decrease here which may have been due to the increased glycogen in the blood from the feed. After slaughter, this glycogen could have formed lactic acid to lower the pH.

The pH of hog No. 38, which was given 16 hours rest with water only is represented in Figure 7.

Figure 8 illustrates the pH of hog No. 39, given 16 hours rest, feed and water. In both hogs (Nos. 39 and 41) given feed and water with a 16-hour rest period, there was a greater increase in the pH soon after slaughter than in the hogs (Nos. 38 and 40) given only water during the 16-hour rest period.

In all 4 of the hogs given 16 hours of rest, there appeared an increase in the pH soon after slaughter. This increase was not found in the animals given a 2-hour rest period. In general it was noted that the pH of the Psoas major had a tendency to have a higher ultimate pH than the pH from the hams made by the direct insertion of the electrodes.

Four pH curves obtained on a portion of the ham removed from the carcass are illustrated in Figures 9, 10, 11 and 12. There appeared to be very little if any difference in the pH of the ham by re...oving it from the carcass.

Because of this finding, future work can perhaps be based on inserting the electrodes directly into the carcass. This would facilitate large-scale pH determinations with no resulting economic loss due to damaging the meat.

THE pH DETERMINATIONS OF THE PSOAS MAJOR

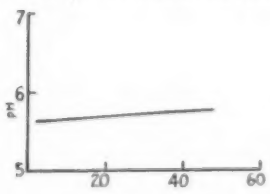

Figure 5
Hours after slaughter

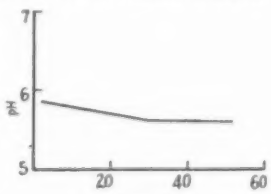

Figure 6
Hours after slaughter

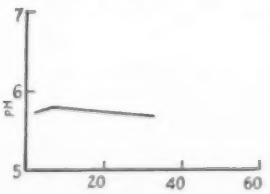

Figure 7
Hours after slaughter

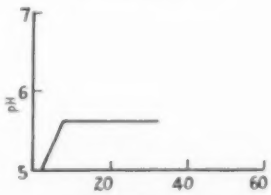

Figure 8
Hours after slaughter

THE pH DETERMINATIONS OF THE SLICE OFF THE HAM

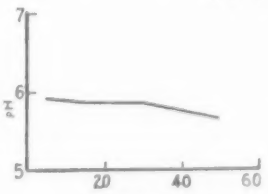

Figure 9
Hours after slaughter

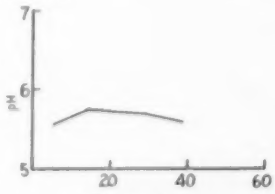

Figure 10
Hours after slaughter

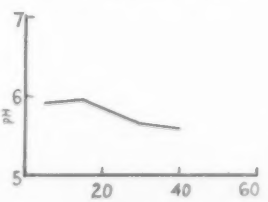

Figure 11
Hours after slaughter

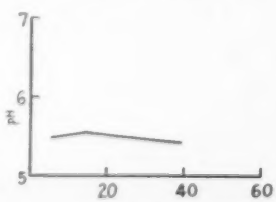

Figure 12
Hours after slaughter

The pH determination of one of the loin roasts which were frozen on a —10° F. plate freezer and then thawed for 24 hours in a 34°-36° F. cooler is represented by Figures 13, 14, and 15. The loin was removed at the third rib and at the hip bone. It was cut into 3 roasts of equal length. Each pH determination was made by removing a chop or slice approximately ¾ of an inch thick from the posterior end of the roast. The roast was then frozen and thawed and the process was repeated.

The observations noted were the difference in pH between the roasts. In almost all cases, the blade end roast had a higher pH than either the center or loin end roasts. The loin end roast appeared to have the lowest pH in most cases. It appears likely that the pH of a pork loin decreases from blade end to loin end.

The pH determinations on pork sausage packaged by 3 methods are illustrated in Figures 16, 17 and 18. Figure 16 represents the 2-pound package wrapped in cellophane with a "Tite" protective covering. Figure 17 graphically illustrates the 2-pound package wrapped in "Tite." Figure 18 illustrates the 12 x 12 x 2 inch package wrapped in "Tite." Because of the small number of packages, comments concerning the effects of different wraps and methods of packaging on the pH of the sausage are inadvisable.

pH DETERMINATIONS OF LOINS DURING REPEATED FREEZING AND THAWING

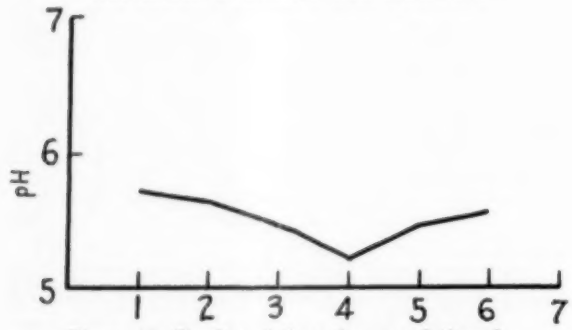

Figure 13. Number of times frozen and thawed.

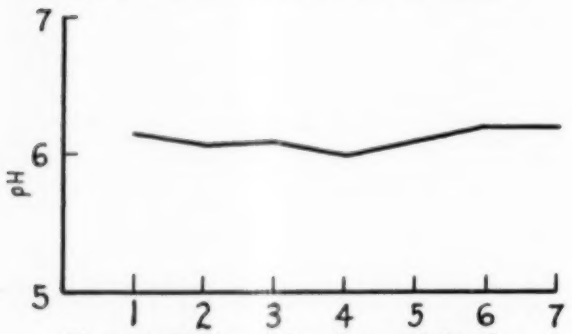

Figure 14. Number of times frozen and thawed.

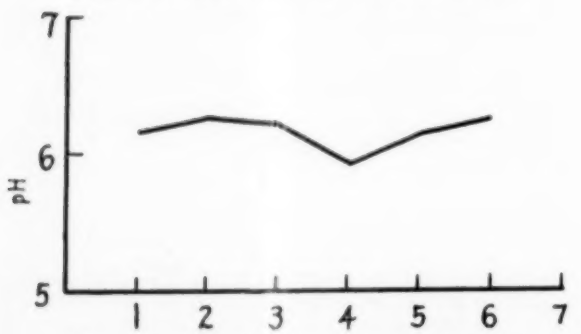

Figure 15. Number of times frozen and thawed.

pH DETERMINATIONS OF SAUSAGE DURING REPEATED FREEZING AND THAWING

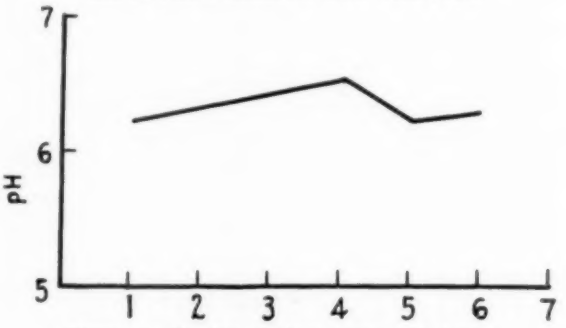

Figure 16. Number of times frozen and thawed.

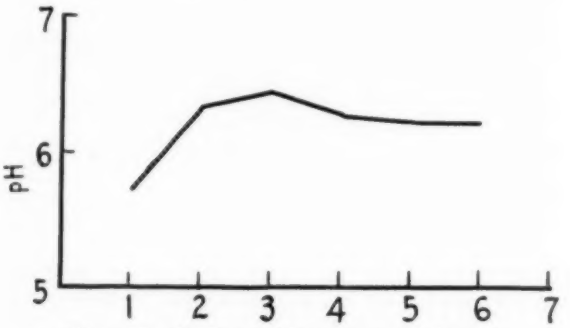

Figure 17. Number of times frozen and thawed.

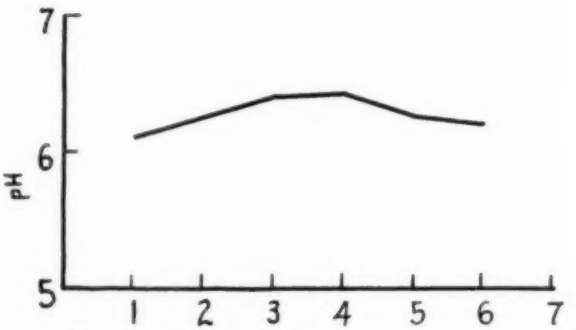

Figure 18. Number of times frozen and thawed.

SUMMARY

Determination of pH by inserting a glass electrode in conjunction with a calomel reference electrode gave an accurate pH of the tissue.

There appears to be a rise in the pH of fresh pork following slaughter and terminating at approximately 6 hours after slaughter. There also appears to be a rise in pH at approximately 48 hours after slaughter.

The pH of hams determined by inserting the electrodes directly into the ham, and the pH of a portion of the hams removed from the carcass gave approximately the same value.

In hogs rested 2 hours and given *only water* there appears to be little change in the pH from the 6th hour to the 48th hour after slaughter. Hogs rested 2 hours and given *feed and water* appear to have a greater variation in pH from the sixth to the 48th hour following slaughter than do hogs given rest for 2 hours and only water. Hogs given 16 hours rest with *only water* had a smaller rise in pH soon after slaughter than hogs given *feed and water*.

The ultimate pH of the Psoas major appeared to have a higher pH value than the ham.

Repeated freezing and thawing of fresh pork appeared to have little, if any, effect on the pH value.

The blade end of the pork loin appeared to have a higher pH value than either the center or loin end. The loin end appeared to have a lower value than either the center or blade end. Thus, the pH value appeared to decrease from the blade end to the loin end.

LITERATURE CITED

1. Bate-Smith, E. C. The physiology of rigor mortis. *Report of the Food Investigation Board*. (1937).
2. Bate-Smith, E. C. The physiology and chemistry of rigor mortis, with special reference to the aging of beef. *Advances in Food Research I*. (1949).
3. Callow, E. H. Transport by rail and its after-effects on pigs. *Report of Food Investigation Board*. (1936).
4. Callow, E. H. The after-effects of fasting. *Report of the Food Investigation Board*. (1938).
5. Callow, E. H. The pH of muscular tissue. *Report of the Food Investigation Board*. (1939).
6. Empey, W. A. Studies on the refrigeration of meat. Conditions determining the amount of drip from frozen and thawed muscles. *J. Soc. Chem. Ind.*, **52**, 23T (1933).
7. Fenn, W. O. Protoplasma 24.
8. Ingram, M. Muscular fatigue, pH, and the development of bacteria in meat. (Paper for publication.) Low Temperature Station for Research. University of Cambridge, Cambridge, England. (1948).
9. Kidd, Franklin. Report of the Director of Food Investigation for 1948; Report of the Food Investigation Board. (1948).
10. Madsen, Jens. Investigations concerning the keeping qualities of sugar fed pork. *Nord. Jordbrugsforsk.*, **5**, (6) 340 (1943).
11. Ritchie, A. D. Reaction of active and resting muscle. *J. Physiol.*, **56**, 53 (1922).
12. Saib, L., and Cook, W. H. Relation of pH to drip formation in meat. Can. J. Res., 16D, 225 (1938).
13. Voegtlin, C., Fitch, R. H., Kahler, H., and Johnson, J. M. The hydrogen-ion concentration of the mammalian voluntary muscle under various conditions. *Am. J. Physiol.*, **107**, 539 (1934).
14. Watts, Betty M., and Peng, Da Hwei. Rancidity development in raw versus precooked frozen stored sausage. *J. Home Economics*, **39**, 88 (1947).

Quality Control—Its Significance, Implementation and Practice

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Professional people often have the unhappy faculty of not making their knowledge clearly understandable to those in the upper echelons of management nor, for that matter, to the general public. That this is a common circumstance was ably outlined in a pertinent statement made by Mr. Richard S. Aszling, assistant public relations director of the Borden Company, during the symposium held in New York on January 15, 1952, at the Inter-Industry Conference on Chemicals in Foods sponsored by the Manufacturing Chemists' Association which is quoted in part below:

"Communicating successfully with 'ore groups of people is not an easy thing to do. Today it is more difficult than ever before because the people with whom we want to communicate are besieged throughout their working hours by a great number of other people who also want to communicate with them, and so it becomes a question of whose techniques are the most effective. In this respect, chemists are starting further behind scratch, perhaps, than some other would-be communicators because they are handicapped by technical jargon. The job in communicating with the public is first and foremost one of semantics—that is, the translation of professional language into word-symbols that will get through to the public mind. The very word 'chemical' itself is a handicap because it has adverse overtones. To many laymen, a chemical is something that smells bad, explodes or poisons, and you can't blame them for not wanting one in their food. If you tell an average businessman that his wife added monosodium glutamate to his vegetable soup, he would probably suspect her of trying to collect his insurance. But you call the same substance Accent, put it up in handsome packages, and advertise it with sophisticated copy in the *New Yorker* magazine, and the same man will insist that his wife use it."

QUALITY CONTROL—AN ANALYSIS OF ITS MEANING

We can surely agree that the charge Mr. Aszling made concerning technical jargon is well founded. It is equally applicable to the loose usage of such a common every-day word as "quality." Just what do we mean by quality? What is quality? We certainly cannot hope to control it if we cannot define it or measure it. It is derived from a Latin word meaning "how constituted." "Quality" can refer to peculiar excellence or distinctive character, trait, power, capacity or virtue. It can also refer to class, kind, or type. Depending upon your interests, or your profession, "quality" can also refer to that property of tone which may distinguish it from another tone having the same pitch and loudness, that character in logic of being affirmative or negative, or that identifying character of sound in phonetics.

The meaning of "quality" in practice. From the viewpoint of a production manager, the philosophical definition of being an attribute or property is perhaps the one best describing the pragmatic significance of "quality" in actual industrial practice. However, *the meaning of quality we as men of organized practice are primarily interested in is "that which is predicable of anything as one of its characteristics"*—and the importance of the element of prediction cannot be overemphasized. In teaching food engineering, for example, we are constantly emphasizing to our students that all industrial food preparation and processing is concerned with intentional and controllable changes in composition, phase and/or form of the essential nutritive elements of the final product.

All engineering professions are concerned with the design, construction and operation of industrial plants and processes in the performance of which the results are predictable in a

variety of production units whether they be expressed in the accountant's terms of costs, the engineer's language of B.T.U.'s, kilowatts or horsepower, the sales manager's recognition of improved producer-consumer relations, or the production manager's more efficient use of equipment or maintained uniformity of product.

It can be readily appreciated that in referring to the quality of anything as complex as a food product, with its variable organoleptic characteristics, we use the term in a collective sense. Quality in a food product consists of a variety of characteristics all of which we might refer to, in the engineering sense, as increments— and increments to be controlled intentionally insofar as it is humanly possible to do so! We must avoid the delusion that all that is involved in quality control can be expressed as the whole being equal to the sum of all its parts. Such a delusion would come in the supposition that the parts are always in precise units which, incidentally, is never the case. Thus we soon learn that we are confronted with circumstances in which the increments of quality are variable factors. Furthermore, in mass production practices such increments have to be resolved statistically if any reasonable consistency of performance is to be predicted, realized and reproduced as we shall presently demonstrate.

In evaluating foods we have in addition to the sensual precepts of quality, the added burden of resolving the physiological and psychological factors of age, health, sex, experience and acuities—to mention but a few. And then, just to keep track of all the possible increments of quality, we can't ignore the specifications of the various ingredients and intermediates, the production practices involved in making our food product or products, as well as any environmental factors involved as increments of quality. And finally, these various increments of quality are not of arithmetical progression as is constantly being proven in that court of last resort—the consumer.

He, or *she*, applies certain acceptability criteria including price, appearance, taste and healthfulness. The first three criteria are self appraised with no particular reliance upon the manufacturer. The increment of healthfulness finds expression in confidence in the integrity of the manufacturer and the diligence of the regulatory officials for healthfulness includes the subincrements of cleanliness, freshness, wholesomeness, purity, safety, nutritive value and normal character. However, the consumer does not judge quality as the sum of all these increments but rather as their product. For if a food product is priced right, looks attractive and is reeking with vitamins but does not have an acceptable palatability—what happens? There is no sale, of course. And no sale means zero acceptability. In other words, if all the quality increments rate acceptable but one, it is apparent that the equation of consumer acceptance is the product of the quality increments. For as any of the quality increments approach zero, the equation of acceptability is similarly resolved.

The goal is "reproducible performance." Assuming that we have discussed adequately a working definition of "quality," our next task is to define quality control. Obviously we need first of all to establish what "control" involves. Webster informs us the word itself is derived from two French words "contre" and "role" meaning counter register or catalogue. Therefore, stated in its simplest terms, quality control should provide a counter register or catalogue of the essential increments of its "how constituted" character. Another way to state it would be the establishment and application of "how constituted" indices of predictable and reproducible performance.

Quality control is, therefore, predicated upon an effective application of accumulated or catalogued knowledge and experience. Knowing the facts is prerequisite to dealing effectively with them. The most effective way that has so far been developed for getting at facts about quality characteristics is to use statistical methods. We appreciate this statement will create some revulsion for there is an almost universal fear or dread of statistics by those who do not understand their utility. Statistical methods offer us a most practical means of dealing with inexactness. Statistics are generally considered as useful only to insurance companies. We can readily concede their usefulness to that industry with their admittedly complex problems of cataloguing vital human characteristics. For with all the variables involved, the insurance companies have done an admittedly superb job of calibrating, controling and predicting their risks.

THE ROLE OF STATISTICS IN QUALITY CONTROL

There is no field of human material experience that does not function in a statistical manner. For as long as we use materials, men, methods and machines, we will have problems of quality variation and control. The proper application of statistical methods can provide a better uniformity of quality, better utilization of raw materials and equipment, and improved performance.

The important thing to keep in mind in statistical methods is that we are dealing with variables—and incidentally they are never precise for we have nothing exact to measure or measure with. Another significant fact to remember is that the proper use of statistics provides a means for developing dependable estimates of what our control factors will provide. We can solve equations with mathematics (a true science) while we can only infer solutions with statistics. Some of the basic factors or variables normally encountered in the food industry in the control of quality include:

a. Procurement or selection of raw materials, ingredients, water and supplies.
b. Methods and conditions of receiving and handling raw materials and supplies, or storing and of shipping final products.
c. Means and methods of cleaning, grading, selecting and blending raw and ingredient materials.
d. Selection and installation of processing, storage and packaging of product.
e. Methods and means for cleaning and sanitizing equipment.
f. Operation and care of equipment.
g. Performance specifications:
   1. Cleanliness and bacterial sterility
   2. Time, temperature processing detail
   3. Production rates, yields, etc.
   4. Check analysis and examination of ingredients and products
   5. Organoleptic grading of products
   6. Physical characteristics of products

Specifications as quality control "targets." The working basis of a quality control program is a definition of the desired quality of product reduced to writing in the form of an approved set of specifications. Obviously, perfection in quality control would result in constantly and precisely meeting specifications. This is an ideal never attained nor attainable. A specification, therefore, should be looked upon as a target. Those with rifle range experience will recall that a target has a bull's-eye surrounded by a series of circles of ever widening diameters. Even a crack-shot does not put every bullet through the same precise hole in the bull's-eye. He has an area of tolerance depending upon a number of variable factors. Consequently any practical specification should be stated as a target with tolerance limits set wide enough to encompass permissable variations—yet narrow enough to insure consistent acceptability. Normally, adherence to such a policy enables the ready detection of accidental errors. This, in turn, enables correction without undue difficulties.

Specifications, incidentally, cover more than a description of the final product. They deal also with inter-

mediates, raw materials, operating procedures, etc. Limits should not be changed to conform to performance but only to *measured demands. Significant changes in a product should be undertaken,* therefore, *only after statistical studies of the market have demonstrated a need for the incidental alterations.*

Measuring performance. *Another major consideration in a quality control program is to measure performance with respect to intentions*—the product being tested for adherence to specifications. In this connection it is dangerous to attempt to gauge performance by comparing the product being tested with those of competitors for, inevitably, adherence to specifications is lost sight of by applying criteria of quality that have no pertinence to quality maintenance or control. When comparisons are made upon competitive products, the specific quality characteristic or characteristics of significance or evaluation should become the target or targets of appraisal. Furthermore, in testing products for adherence to specifications, intermediates as well as raw materials and ingredients should be included so that blending practices might be predetermined and provided, for example.

We have proposed some definitions of quality control as well as discussed a few fragmentary examples of indices which might be used for evaluating and predicting performance. In addition, we have suggested that statistical methods offer us the best means for implementing quality control in spite of some of the normal antipathy to such methods. What is sometimes lost sight of is that a successful business is a complex, competitive and demanding human organization. As corporate enterprise becomes more complicated and a business grows in size, scope and service, it becomes more and more difficult to assemble and interpret the various factors.

Reducing facts to figures. To revert to definition, *we find the true meaning of statistics to be the science of the collection and classification of facts on the basis of relative number or occurrence as a ground for induction.* It resorts to the practice of reducing classified facts to numbers or figures, thereby permitting a mathematical approach. Note that we have stated "mathematical approach" for that is all that it is. And remember, "strange as it may sound, the power of mathematics rests on its evasion of all unnecessary thought and its wonderful saving of mental operations." Yet, while mathematics is an exact science and permits precision in theoretical solution, statistics is a science that deals with inexactness for the purpose of measuring, and predicting, probabilities—not certainties. At best, it sifts the significant from the insignificant.

It is difficult, at times, to understand the reluctance of some executives in excepting statistical methods. For, as Charles W. Eliot said: "All business proceeeds on beliefs, or judgments of probabilities, and not on certainties. Actually, control of service, products, and performance has been tremendously improved through scientific use of probability factors and statistical manipulation of classified information to *make the most out of the significant.* In addition, there are two basic features of scientific control in using probability factors which should attract an executive's approvel: it doesn't cost much to install a system and the return on the incidental investment in a properly applied program is high.

It might be well, also, to keep in mind that the application of statistical techniques does not have to be the executive's burden. He can rely on the future probabilities of significant factors based upon the data presented when analyzed by a competent statistician, staff, or consultant. While it is true that good judgment cannot be replaced by control techniques—which fact many of our government bureaus appear to disregard—good judgment can "draw a bead" on the significant elements remaining after screening out the insignificant factors. Also, while the outcome of a single future event cannot be predicted absolutely, the element of risk in a group of them can be calculated, at least in a great majority of cases. Intuition and judgment can then be focused on the non-predictable features.

Gathering and presenting the data. The gathering of figures or data is, of course, essential in implementing any control. However, it is axiomatic that the purpose of their gathering receive primary consideration—hence, specifications play their role. *The proper use of the data must receive carefully tested consideration* lest they prove futile or ineffective. Graphical presentation of the variables is one of the most effective and most readily understandable forms of depicting performance—and particularly so, when points of reference are indicated. A quality control chart presented as a sort of target for the operatives to consult gives them a measure of their proficiency. Actually, it becomes a point of reference that readily builds an "esprit de corps" as it stimulates a competitive spirit to "hit the bull's eye" as often as possible to gain the incidental recognition of a high degree of performance—a psychological factor of paramount importance.

CONCLUSION

A final word of caution should be sounded. Statistics in themselves solve no problems nor insure any quality control. That old saw fits—"some persons lean on statistics like a drunk on a lamp post, for support rather than illumination." Statistical methods apply when there is a sufficient catalogue of information to allow statistical treatment. All statistical methods hinge upon the law of probability and these laws of chance touch all things which can be measured..

The frequencies observed in measurements provide the theoretical bases upon which to analyze the incidental data—and these are primarily the concern of the experts. Just as the business executive depends upon his comptroller to guide him in the control of financial matters, the production manager must depend upon the statistician to guide him and his management in the control of quality factors. Neither the executive nor the production manager need be expert in computational or statistical techniques although it sharpens his perceptions when he is so equipped.

Therefore, it would appear in any mass production of processed foods, the statistician is as important to the production manager in gauging the quality control as the accountant is to the treasurer in gauging the financial control of his company's operations.

Surface Darkening of Foods in Glass Containers With Metal Caps

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(Manuscript received September 18, 1952)

The corrosion mechanism of tinplate when used as a closure for glass jars has previously been given. Herein information regarding other problems presented by metal closures on glass jars is presented. There is little precedence in the behavior of the tin can to explain them. One is the surface darkening of some products. A second is the tendency of the food adhering to the metal cover of the glass jar to dehydrate. This seems to have a point in common with loss of vacuum.

Tinplate used in food containers behaves differently in an all-tinplate can than when used as a closure on glass jars. Much has been published on the behavior of the food and tinplate toward each other in an all-tinplate can *(2)*. Tinplate as a closure for glass jars has presented new problems that have been most marked with strained foods for babies.

A previous publication *(1)* gave the corrosion mechanism that sometimes leads to perforation of the tinplate closures on glass jars. The present paper presents data that throw light on the surface darkening of some foods in glass jars; it also gives an explanation of the tendency of the small amount of food that adheres to the inner side of the metal closure on glass jars to dehydrate.

The problem of surface darkening in glass containers with tinplate caps pre-dates strained foods in glass jars. The notable example is ketchup. The view has long been held that the dark pigment in darkened ketchup involves tannin or similar compounds and iron and is augmented by oxygen, which assures ferric iron. Avoidance of oxygen in the bottle has been effective in preventing this. As pointed out *(1)* the cathodic periphery of the cap on glass jars induces anodic iron corrosion (and sometimes perforations), under anaerobic conditions within the jar. This imparts iron to the surface food, but it does not follow that there is a close correlation between perforations, or iron imparted to the food by corrosion of the cap, and surface discoloration. As will be shown, minute amounts of iron are effective in the pigmentation. Other conditions may well be the controlling factors—while perforation is strictly a matter of galvanic iron corrosion.

It is generally recognized that certain foods tend to suffer surface darkening more than others. (This is evident from the products discussed below.) It is the composition of the food that is involved in this case, and there is no possibility for correcting the difficulty by any treatment of the food. As is recognized in industry and as will be indicated, the seal of the glass jar with the metal cap permits air seepage in the course of time and loss of vacuum results. Although the elimination of oxygen by deaeration of the product and displacing air in the headspace tends to delay and minimize surface darkening, this is by no means a solution to surface darkening.

There remains the possibility of solving this problem by the elimination of the source of the iron. An attempt was made to do this by the use of aluminum caps as described in the following experiments. As will be seen from the data, corrosion of the caps was not the only possible source of iron not inherent in the food.

EXPERIMENTAL

Although it is well known that it is necessary to enamel aluminum exposed to foods on the acid side of neutral, some unenameled alumnium caps were tried. The result was that in time a white basic aluminum sludge appeared on the surface of the food and the caps were "blown"—that is, lifted from the seal by the hydrogen gas formed. Incidentally, with strained foods, tinplate caps, whether plain or enameled, have never been observed to be blown in this manner; analysis of the head space gases has never revealed hydrogen. This is important evidence of the nature of the corrosion that causes perforation, as was previously pointed out *(1)*.

Comparison was made using aluminum caps and tinplate caps coated with the same enamel.[a] The aluminum permitted a higher baking temperature and there was a striking difference in the character of the two coatings. The enamel on the aluminum caps was difficult to remove even after several days exposure to acetone, whereas the enamel on the tinplate caps could be wiped off easily with a cloth after 10 seconds of exposure to acetone. The highest baking temperature possible has been found desirable in tinplate cans but there is a limitation—the melting point of tin.

The enamel on the aluminum caps did not fracture, as it did on the tinplate caps, at the point where they rest on the upper edge of the jar. Nor was there evidence of corrosion on the aluminum after removal of the enamel. The tinplate caps, however, revealed definite areas of corrosion after the removal of the enamel, evn though the enamel appeared to the naked eye to be perfectly intact. Evidently outside exposed aluminum does not set up the galvanic couple with inside exposed metal in aluminum caps as is the case with tinplate caps *(1)*.

In the first small scale experiments with aluminum caps, clamps, as shown in Figure 1 were used to hold the caps in place on the jars during processing in steam, to obviate processing under water with air pressure. Surface darkening did not occur with aluminum caps, even with products in which surface darkening was most pronounced with tinplate caps. Moreover, there was no evidence of any corrosion of the aluminum and the enamel coating was intact. This was not the case with tinplate caps.

The question then arose as to how the softer aluminum caps would withstand processing as usual in water under air pressure and subsequent handling and shipping. For this purpose, several 36-jar cases of each of three products were packed in July, 1950, over a regular commercial line—a total of about 20 cases—half the jars being closed with aluminum and half with tinplate caps. Both the aluminum and the tinplate caps for each product were numbered consecutively and stacked alternately in the capping machine. This made it possible to identify the jars that

[a] The tinplate caps and the aluminum caps used, and the steri-seal capper to cap the jars, were kindly provided by the Anchor Hocking Glass Corporation.

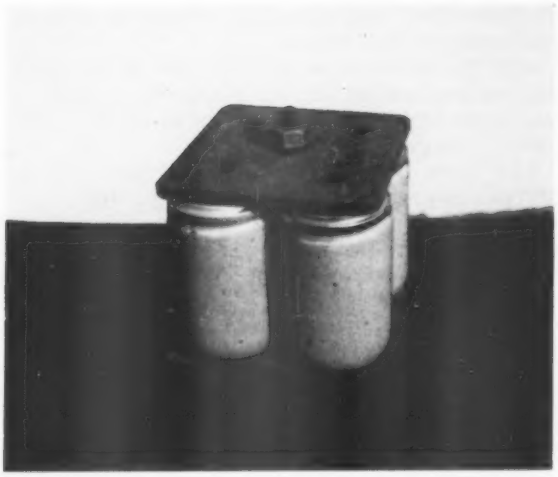

Figure 1. Aluminum caps, held in place by clamps during steam processing; processing under water with air pressure was thereby avoided.

accompanied each other through the line and through subsequent handling, storage and examination. The jars of a pair were never separated before they were finally opened for examination. Nineteen cases were shipped from Camden to Chicago in a full carload of canned products and then shipped back to Camden via LCL freight. The 3 products were the Chicken Soup, Lamb Soup and Vegetable Soup described previously *(1)*.

From time to time a number of pairs were selected at random and examined for vacuum and condition of contents, the first examination being a few days after packing and before shipping. The vacuum was taken with a guage that held its vacuum from jar to jar to minimize the effect of its volume on the vacuum. The vacuum record is shown in Table 1. There was considerable loss of vacuum after about 300 days with each soup. In the absence of hydrogen, this can be explained only by air seepage.

The dehydration characteristic. Another characteristic of strained foods in glass jars with metal caps that does not manifest itself with the same products in a can is the dehydration of the small amount of food that adheres to the inside of the cap. This takes place gradually during several months of storage and is not to be confused with the scorching during processing that occurs with some products in cans also. This dehydration often progresses to such an extent that the food takes on an unattractive brownish appearance and permits peeling the food off as a film. It presumably results from the cap more promptly acquiring the temperature of the surroundings than does the jar or the food in it when the storage temperature rises. This would tend to evaporate water in the food on the cap, and the vapors would promptly condense on the surface of the cooler, moist food in the jar. With a reverse change in temperature the thin layer of food on the cap, as it loses more and more of its moisture, would not be expected to condense vapors readily. It should be clearly understood that this partially dehydrated food adhering to the cap is not the "surface food" herein discussed and used for analysis as described below. The surface of the products discussed is more apt to be covered with a thin layer of liquid due to synaeresis, with never any sign of dehydration.

The dehydration of the food adhering to the cap offers a plausible explanation for the loss of vacuum. If the food on the cap dehydrates, it seems inevitable that a capillary film through the seal would dehydrate and thus facilitate air seepage. With cans it has been observed that when they are empty they are more apt to permit air seepage through the seal with loss of vacuum than similar cans similarly sealed but containing moist food. This indicates capillarity plays a part in hermetical sealing of cans and no doubt it does in glass jars also. This capillary film, as previously indicated *(1)*, also acts as an electrolyte to complete the galvanic circuit between inside and outside metal. The great pressure in the seal of cans renders any capillary film insignificant in conducting the current of a galvanic couple.

RESULTS

On examining the Lamb Soup 105 days after packing (Table 1) 9 of the 21 jars with tinplate caps showed serious surface darkening; in 6 jars the discoloration was slight to moderate. Unexpectedly, there was slight to moderate surface darkening in 6 of the 21 jars with aluminum caps. In the examination, 308 days after packing, of the 9 jars of Lamb Soup with tinplate caps there was pronounced surface darkening in 2 jars, serious darkening in 2 jars and slight in 1 jar. Of the 9 jars with aluminum caps there was serious darkening in 2 jars and slight darkening in 1 jar. After 17 months there was surface darkening in occasional jars with aluminum caps while in nearly all the jars of Lamb Soup with tinplate caps the surface darkening was pronounced. There was little surface darkening with Vegetable Soup or Chicken Soup. This has been the experience with this product in several years of packing, indicating some foods contain a substance that enters into the pigmentation while others do not.

Without further evidence, surface darkening in a jar with an aluminum cap would tend to discredit the view that iron plays a part in the discoloration. The further evidence is provided by a determination of the iron content of 10 g. of surface food and of 10 g. of bottom food of the same jar. Pairs of jars were taken at random for analysis. For iron determination the food was dry ashed. The ash was taken up in dilute nitric acid and after adding thiocyanate the iron was determined colormetrically by the use of a spectrophotometer. This procedure is accurate to within 0.5 p.p.m.

TABLE 1

Vacuum correlation of baby foods with storage time

Days after packing	No. of pairs	Max		Min.		Ave.	
		Al.	Tin	Al.	Tin	Al.	Tin
Lamb Soup							
6	5	23	21	16	17	18.9	19.1
63	23	23	23	12	15	20.2	20.0
105	21	28	27	15	15	20.1	21.1
160	12	23	24	14	13	18.8	18.9
308	9	20	19	10	8	14.7	15.3
490	6	18	19	8	9	14.2	13.4
545	4	19	20	5	5	12.3	14.3
Chicken Soup							
5	7	26	26	22	18	25.5	24.4
62	27	28	28	22	19	25.5	25.5
104	27	28	28	20	21	25.8	26.0
129	3	24	25	24	24	24.5	24.7
307	11	22	21	11	9	16.5	14.6
476	5	19	19	15	11	17.4	14.6
594	19	23	23	11	10	19.3	18.4
Vegetable Soup							
3	6	20	21	12	13	15.8	17.1
59	25	22	21	14	14	18.2	18.6
102	28	24	23	11	13	18.8	18.8
126	3	23	22	18	18	21.0	20.0
304	11	17	18	12	8	14.1	11.7
473	4	13	14	10	7	10.8	9.6
541	31	19	19	5	7	11.9	12.8

TABLE 2

Iron content (p.p.m.) of the top and bottom food of a jar and degree of surface discoloration (17 months after packing)

Pair No.	Tinplate caps				Aluminum caps			
	Vacuum	Degree of discoloration	Iron in		Vacuum	Degree of discoloration	Iron in	
			Top	Bottom			Top	Bottom
Lamb Soup								
3	19	4	14.3	6.8	17	0	7.1	6.5
7	14	4	14.3	4.3	18	0	6.3	6.5
12	18	4	10.2	3.2	20	0	5.5	4.8
34	18	3	8.3	3.5	19	0	4.8	4.5
36	10	4	14.4	5.0	8	3	15.5	5.7
37	18	4	15.8	4.8	18	0	7.3	6.2
62	9	4	13.2	5.5	15	0	6.5	7.0
88	11	4	15.0	4.7	9	3	12.0	4.3
90	17	0	4.5	4.5	8	3	9.5	2.8
Vegetable Soup								
35	14	0	8.5	7.5	10	1	8.0	7.9
61	7	1	8.3	6.3	10	0	8.8	6.3
82	7	1	8.3	6.3	10	0	7.3	7.3

The result of such analyses is tabulated in Table 2, the iron being expressed as p.p.m. The degree of surface discoloration is expressed numerically on the basis of:

(1) *Questionable darkening;* possibly explained by shadows cast by the contour of the surface.

(2) Trace to slight darkening.

(3) Serious surface darkening; leading, perhaps, to questions concerning the wholesomeness of the contents of the jar.

(4) Pronounced and distasteful discoloration that has penetrated to a depth of 0.5 to 1.0 cm.

From the vacuum record in Table 1 it is evident that by 10 months after packing there was considerable loss of vacuum. Since it has been found that hydrogen does not appear in baby food jars to account for this drop in vacuum, it can be explained only by concluding that there has been air seepage through the seal. It is a logical assumption that this is a gradual development and that undoubtedly there was some air seepage earlier than 10 months, for example with Lamb Soup 105 days after packing, at which time the first surface darkening was noticed.

The data in Table 2 disclose that surface discoloration is definitely linked with a higher iron content in the surface food. The surface darkening with occasional aluminum caps also is accompanied by increase in iron content of the surface food. The aluminum cap cannot be the source of this iron and there is no basis for assuming that iron can migrate from the bottom food and concentrate at the surface.

Three possible sources of this iron might be considered:

(1) The periphery of the tinplate caps tend to accumulate rust and this may become detached. This however, occurs to an insignificant extent before packing and it is not believed possible that stacking the caps to place tinplate caps and aluminum caps on alternate jars resulted in iron contamination.

(2) The steam line to the capper may be the source of contamination, but this was avoided by making certain in the installation that no iron would be carried over.

(3) There is evidence that retort water, usually heavily laden with iron, more or less in a soluble form, finds its way through the seal. Caps sometimes "lift" during the process and later reseat themselves. The evidence points to this as being the most likely cause of contamination with iron.

This increase in iron by 5 to 10 p.p.m. in 10 g. represents, respectively, 0.005 to 0.01 mg. of iron. These amounts might be contained in so little retort water as not to be noticed in the jar.

The cap often rests on the top periphery of the jar. The seal is on the side. Under such a condition it is plausible that the pressure on that portion of the cap inside the top periphery of the jar may exert a leverage action that tends to pry the side seal loose. Pressure on a top seal could have no such effect.

The pressure on tinplate caps often causes the enamel to fracture where the cap rests on the upper edge of the jar. The enamel on aluminum caps does not fracture similarily. The higher baking temperature with aluminum evidently enables the enamel to resist fracturing and makes it less pervious to the food liquid.

SUMMARY

Surface darkening with strained foods in glass jars was found to be accompanied by a higher iron content in the surface foods. With tinplate caps this iron may be imparted by the cap. The fact that the surface food in relatively few jars with aluminum caps also contains more iron and becomes dark, indicates retort water has entered the jar through the seal and contributed iron. With aluminum caps there is no surface darkening of the food except when there is contamination with iron. The seepage of retort water through the seal may result from the cap being temporarily lifted and is presumably facilitated by the leverage action of pressure on the central area of the cap to loosen the side seal. There was gradual loss of vacuum in glass jars with the caps and closures used. This becomes pronounced within a year. In this respect tinplate and aluminum caps behaved alike. The air seepage supplies oxygen which assures ferric iron and in this way air seepage augments surface darkening. There was no evidence of corrosion on enameled aluminum caps, after 17 to 18 months, while tinplate caps had corroded areas under the enamel that appears intact.

LITERATURE CITED

1. Kohman, Edward F. Corrosion of enameled tin plate covers on glass containers. *Ind. Eng. Chem.*, **42**, 1578 (1950).

2. McKay, Robert J., and Worthington, Robert. *Corrosion Resistance of Metals and Alloys.* 1936, Reinhold Publishing Corporation, New York.

Recent Advances in Potato Granule Technology[a]

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Potato granules (dehydrated, pre-cooked potatoes in granular form) that reconstitute instantly on addition of liquid are produced commercially by the "add-back" process. In this method a portion of the dried product is added to freshly cooked, mashed potatoes, producing a moist granular mixture that is subsequently dried to a powder. Mechanical damage of tissue cells releases "free" starch that causes the reconstituted potatoes to be undesirably pasty. The amount of "free" starch can be measured as a quality characteristic of potato granules. Package density and particle size are other criteria that can be used in studies of processing factors. Such factors as moisture content of the moist granular mixture, time allowed for moisture equilibration, and drying temperature have been observed to exercise significant effects on potato-granule quality.

Potato granules (dehydrated, pre-cooked potatoes in granular form) are characterized by high package density and great ease of reconstitution. A No. 10 can contains enough for 100 servings of mashed potatoes, which can be prepared simply by mixing with hot water. The product consists in large part of separated, whole tissue cells and, on reconstitution, has a white color and typical potato flavor.

Commercial production received early impetus from the British Food Ministry during World War II and has been under way about 10 years. Production began in America in the post-war years and expanded rapidly to meet military requirements following the outbreak of hostilities in Korea. The method used has been the "add-back" process in which a large portion of dried product is recycled by addition to freshly cooked and mashed potatoes, producing a moist granular mixture that can be dehydrated to a powder. Olson and Harrington (*2*) have reviewed the literature and patents on this method and others for manufacture of dehydrated mashed potatoes.

Figure 1 represents a flow diagram of such a process. Raw tuber stock is washed, peeled, sliced, inspected and trimmed, cooked in steam, allowed to "steam off" (that is, carried on a belt, preferably under a hood to prevent drying, and allowed to cool), mashed, mixed thoroughly with previously dried granules, and dried with or without an intermediate holding period and secondary mix. Generally, drying is accomplished in pneumatic driers, of which several types are in use. Tray drying has also been used on a commercial scale. The dried product is screened and the small percentage that is coarser than about 20-mesh is withdrawn for use as livestock feed. The product that is packaged consists of about 15% of all the material that issues from the drier and is taken from the fraction passing through a screen of about 60-mesh. The remainder, including some of the material passing the 60-mesh screen and all of the intermediate-sized granules, is recycled as "seed" material.

There are no standard methods in the industry for these unit operations. For example, peeling can be eliminated and peel fragments removed from the dried product by screening. Steaming off and pre-mashing are omitted in some operations in which the freshly cooked potatoes are mixed with dried material continuously as they emerge from the cooker. Moisture content of this "pre-mix," type of mixer used, and duration of the period during which the premix is held before drying are known to vary. In addition to differences in the drying equipment used, there are extreme variations in drying conditions. Quality improvement and maintenance of uniformity of product are major problems in the industry. This study presents data indicating the

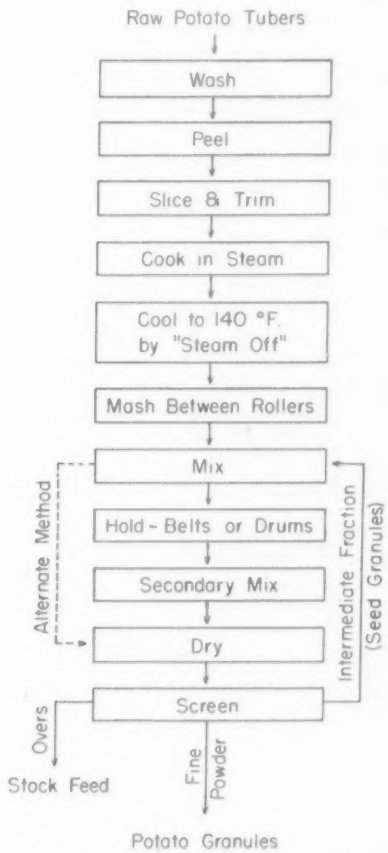

Figure 1. Flow diagram of add-back process for potato granule manufacture.

[a] Presented at the 12th Annual Meeting of the Institute of Food Technologists, Grand Rapids, Mich., June 8-12, 1952.

[b] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

relationship of variation in some of the unit operations to the quality attributes of potato granules produced.

Uniform package density is a very important quality factor, because recipes are generally more useful when expressed in volume measurement. Furthermore, for military procurement a maximum reasonable package density is specified to reduce packaging cost and to increase efficiency in the use of storage and shipping facilities. The texture of the reconstituted product is closely related to the manufacturing method. Rupturing of cell walls liberates "free" starch (starch not enclosed within cell walls), which will cause the reconstituted mashed potatoes to be pasty. The free starch can be extracted from potato granules as an approximate quantitative measurement of this quality factor. Studies on the relationship of free starch in granules to reconstituted mashed product are under way in this Laboratory.

In this report potato-granule quality is considered in terms of package density and amount of free starch. The effect of any change in process on quality of product is masked initially by the fact that 80% of the material in process was already there before the change was made. The particle-size classification of the material used as seed is important. Enough small granules must be present to assure rapid equilibration of moisture in the mixture of seed granules and fresh mash. Therefore, a successful process must provide adequate granulation (adequate mixing and cooling to reduce the moist granular mixture to fine particles) so that a high percentage of material passing through a screen of about 60-mesh can be produced. A process can be considered satisfactory if about 45% of the dried material is in the small-particle-size fraction. Large particles are slow to equilibrate and are not a good seed material. Therefore the coarse material must be removed from the system. An increase in this fraction, as well as a decrease in the fine fraction, indicates improper control of the process.

EXPERIMENTAL METHODS

Laboratory preparation of potato granules. Potatoes of the Russet Burbank variety were washed, sliced to a maximum thickness of about ¼ inch with trimming and rejection of discolored or decayed portions, cooked in steam for 35 minutes, and mixed with seed granules to form batches of about 1300 g. (ranging from 500 g. dried granules with 700 g. fresh mash to 800 g. of dried with 600 g. of fresh) in a 6-quart planetary-type mixer at low speed with a spade paddle. An air stream was directed over the mixing bowl. In runs where "no delay" is signified the product was mixed for 30 minutes and dried; where a delay period was specified, the product was held in an uncovered container for the appropriate period between two 15-minute mixing periods. The moist granular mixture was dried in an air-lift drier in which the product was screw-fed into a reduced-pressure area in a vertical column. (This drier was designed especially for the purpose by Olson and Harrington and will be described in a later publication.) An upward-directed, hot air stream carried the product as it dried. The air-stream velocity was reduced by increasing cross-sectional area and directed downward by a deflector mounted above the column. The product disengaged itself from the air stream and settled to the sloping sides of a collector, while the air escaped upward past the deflector. (See Figure 2 for a schematic drawing of this type of drier.) The product was dried in two or more stages to about 8% moisture content and screened through U. S. standard sieves. The material held by the No. 16 sieve included

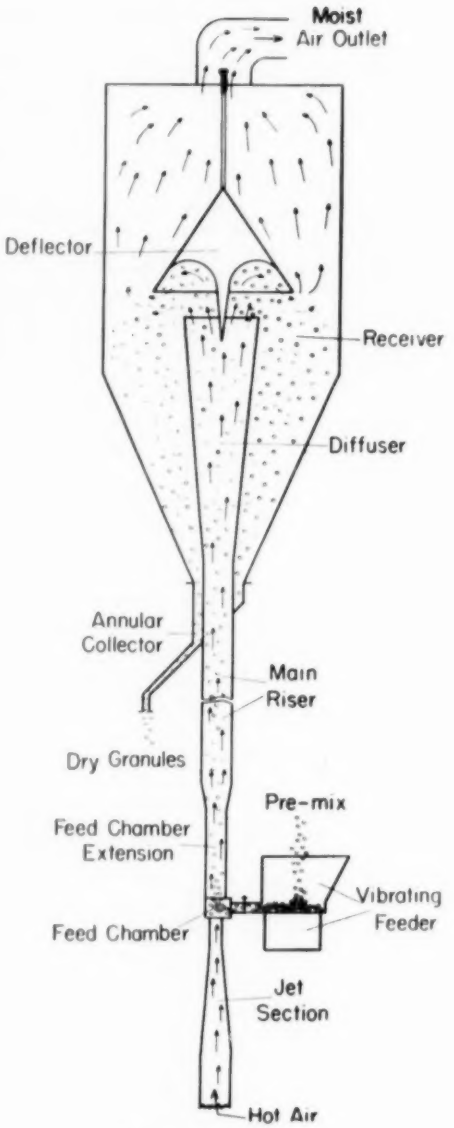

Figure 2. Air-lift drier.

a major part of the peel fragments and was discarded. All of the materials held on the No. 40 and No. 70 sieves plus some of the material passing through No. 70 were composited for seed material for the next cycle. The remainder of minus-70 material was the product yield.

In several experiments, quality of granules produced was related to changes in process variables. The moisture content of the mixture of freshly mashed potatoes and seed granules was varied between 35 and 45% by alteration of ratio of components. No delay was compared with 3 hours of delay. The inlet air temperature of the drier was varied over a range of 212° to 392° F. (100° to 200° C.).

Each process was studied through 9 to 11 cycles to approach a steady state; thus the original seed material was diluted by the addition of fresh mash with each cycle.

Pilot plant preparation of granules. To confirm laboratory results, runs were made on larger-scale equipment (about five-fold) that processed about 30 to 40 pounds of raw potatoes per

hour in a semicontinuous operation. Russet Burbank potatoes were washed and lightly peeled in an abrasion peeler, steam cooked on trays, allowed to steam off to about 140° F. (60° C.), mashed between 2 chrome-plated steel rolls set with 0.050-inch clearance, and mixed with seed granules in a 20-quart planetary-type mixer for 2 minutes at low speed with a dough hook. The mixture of mashed potatoes and seed was further granulated by passage through a system consisting of a ribbon mixer, a slow-moving interrupted-flight screw conveyor, and a secondary mixer which metered the product into a vibrating feeder to an air-lift drier (Figure 2). In a single pass the moisture content was reduced to about 14% and the product cooled and then screened continuously through a commercial-type vibrating separator into fractions held on 16-, 24-, 40-, and 60-mesh screens, and passing through the 60. A fraction of the fine material representing the product yield was dried to about 8% moisture in the laboratory air-lift drier. The coarse fraction was discarded, and the remainder was blended for use as seed material.

Pilot-plant runs were carried on for about 12 hours, but it was not feasible to operate for long enough periods to reach a steady state. Therefore seed granules from the same lot were used on pilot-plant runs for comparison of process variables. Pilot-plant runs were continued until the original seed material had passed through the mixing and drying cycle about three times. Where a delay is specified for a run in the pilot plant, the moist granular mixture was held in about 15-pound lots before it was fed to the secondary ribbon mixer.

Package density measurement. Package density was measured by weighing, to the nearest gram, about 100 grams of the fraction of potato granules passing through the finest mesh used and observing, in a 250-ml. graduated cylinder the minimum product volume obtained by tapping the cylinder vigorously about 20 times on a hard surface, or until the volume was not reduced by further tapping. Package density, expressed in grams per cubic centimeter, is reported for the terminal cycle in the processes studied.

Measurement of free starch. Relative amounts of free starch in potato-granule products were obtained in an empirical manner by determination of the total starch in solution following 25-minute extraction of 2.5 g. of product in 500 ml. of water at an initial temperature of 150 ± 1° F. with stirring for the first 5 minutes. Starch was precipitated from the filtered extract by adding potassium acetate in alcohol, chilling overnight and centrifuging, and determination by the Anthrone method *(3)*. Free starch was generally measured on the terminal cycle of a process studied, although in a few instances composites of the last 3 to 4 cycles were used.

Sieve-size classification of the dried material. Dried granules were classified with U. S. standard sieves. The fraction held by a No. 16 sieve was separated and discarded. The remainder was screened mechanically to separate plus-40, plus-70, and minus-70 fractions. Size classification is reported as the mean percentage of minus-70 fraction of the terminal four cycles for laboratory studies and the terminal four hours of pilot plant operations.

Moisture determination. Moisture in the moist granular mixture and dried product was measured by the toluene distillation method *(1)*. Ten-gram samples were used and distillation was continued 25 minutes.

EXPERIMENTAL RESULTS AND DISCUSSION

Results of laboratory experiments are summarized in Figures 3 (a, b, c), 4, and 5. Figure 3a shows a decrease in package density related to an increase in the moisture content of the pre-mix over a range of 212° F. to 392° F. (100° to 200° C.) in drying temperature when a 3-hour delay time was allowed between primary mixing and drying. Figure 3b shows that the amount of product passing through a No. 70 sieve decreased with increase in moisture content of pre-mix over the same drying temperature range, when no delay or a 3-hour delay

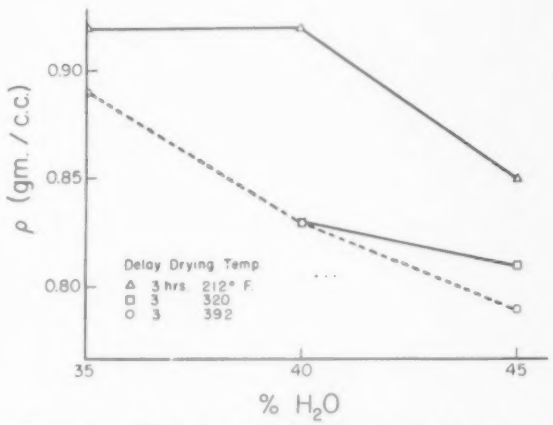

Figure 3a. Effect of moisture content of pre-mix on package density of final product.

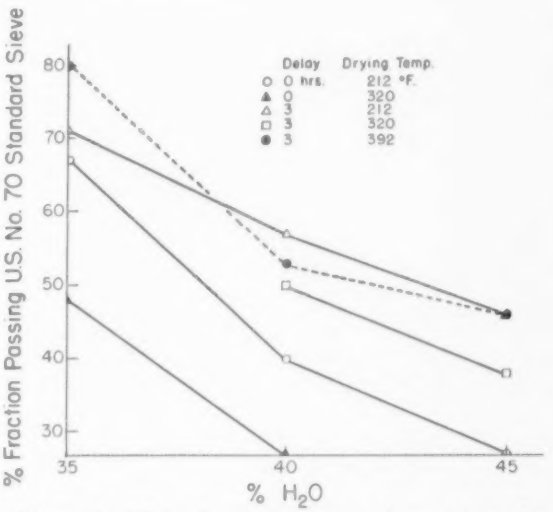

Figure 3b. Effect of moisture content of pre-mix on size distribution of dried product.

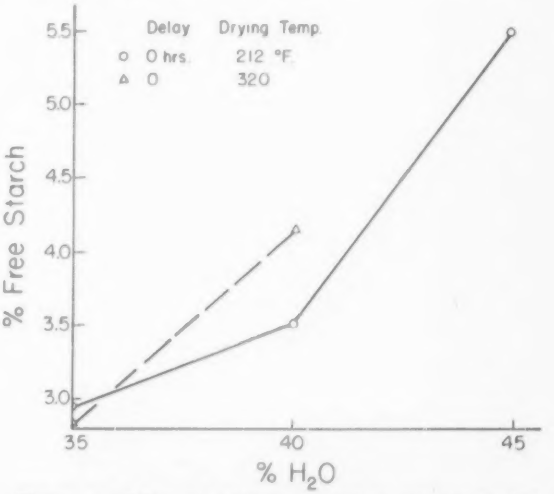

Figure 3c. Effect of moisture content of pre-mix on free starch in the final product.

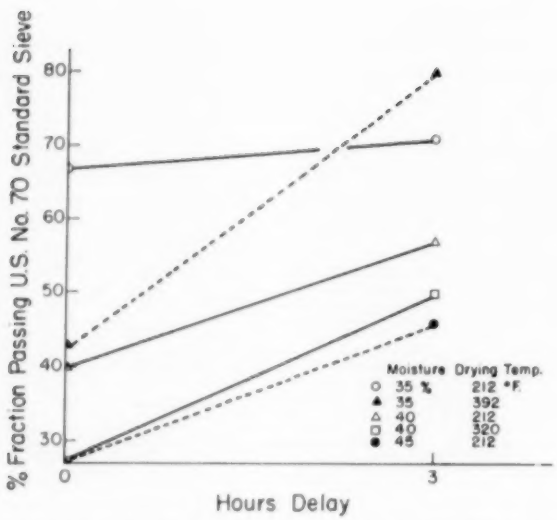

Figure 4. Effect of holding time of pre-mix on size distribution of dried product.

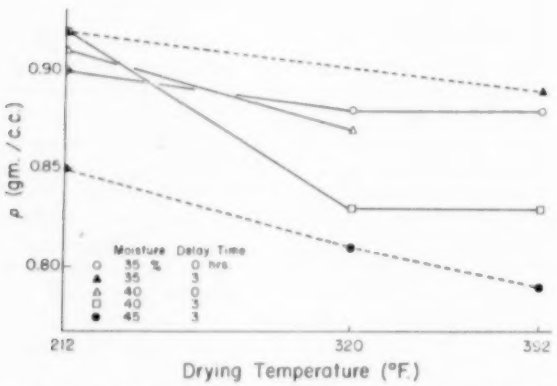

Figure 5. Effect of drying temperature on package density of final product.

was allowed. Figure 3c indicates that the free starch extracted increased with an increase in moisture content of the pre-mix when no delay was allowed. In runs with no delay, minor differences in package density did not show significant trends related to moisture content of the pre-mix, nor did the amount of free starch extracted for runs with 3 hours' delay.

Figure 4 shows an increase in amount of fine-particle-size granules related to an increase in delay or holding time. In Figure 5, a general decrease in package density appears to be related to an increase in drying temperature. (In the equipment used, the input air temperature is closely related to the drying rate and it may be questioned whether or not the drying rate is the controlling variable rather than input air temperature. New equipment is being designed to answer the question.) Delay time did not appear to influence significantly the package density or free starch; nor did drying-temperature differences affect the percentage of material passing through a No. 70 sieve or the percentage of free starch.

Pilot-plant runs were made to observe results obtained when moisture content of the pre-mix and delay time were varied. In Table 1, runs Ia and Ib were made under comparable conditions, as were runs IIa and IIb. Raw material and processing procedure differed slightly between the two series, so that validity of cross comparison between groups I and II is questionable. However, package density and percentage of material passing through a 60-mesh screen decreased with increased moisture in the pre-mix, and percentage of material passing a 60-mesh screen was higher with a three-hour delay than with no delay. These data confirm the trends observed in the laboratory experiments. Data on free starch show no significant differences in the pilot-plant runs, possibly because of inadequate recycling. While only a few cycles may be adequate to show significant

TABLE 1

Effect of process variables on product quality (pilot plant)

Run	Process variable studied	Package density (g./cc.)	—60 Fraction %	Free starch %
Ia	Moisture content of pre-mix, 40%	0.86	62	2.0
Ib	Moisture content of pre-mix, 35%	0.90	72	2.0
IIa	Delay time, 0 hours	0.84	58	2.6
IIb	Delay time, 3 hours	0.85	67	2.4

effects of process variables on some quality attributes such as package density, other quality factors, particularly if differences are small, may not be observed to differ until the original seed material is diluted with fresh potatoes by recycling to the approach of a steady state.

Because of the usual limitations that exist in extrapolating the results of laboratory and pilot-plant research to commercial operation, these data are, of course, not definitive. However, since these relative values have established well defined trends over a broad range of controlled variables, relationships can be drawn that should be applicable to commercial operations. By application of the findings presented here, a commercial processor was able to increase the package density of his product. He accomplished this improvement by operating with a lower moisture content in the pre-mix. He was also able to account for fluctuations in package density caused by changes in inlet air temperature of his drier in accordance with the trend shown in the laboratory experiments.

CONCLUSIONS

On the basis of the laboratory data, confirmed in the pilot plant, it can be concluded that for the add-back process of potato granule manufacture:

(1) With decreasing moisture in the pre-mix, in the range of 35 to 45 percent,

(a) Package density increases when a suitable delay time has been allowed.

(b) Minus-70 fraction of dried product increases, and

(c) Amount of free starch decreases if no delay time is allowed.

(2) With increase of delay time from none to 3 hours, the minus-70 fraction of dried product increases.

(3) With decreasing drying temperature from 392° to 212° F. (or, perhaps decreasing drying rate as limited by equipment used), package density increases.

Acknowledgments

The authors are indebted to Ray W. Kueneman and members of his staff at the J. R. Simplot Company, Caldwell, Idaho, to R. M. Stephenson of Basic Vegetable Products Company, Vacaville, Calif., to J. M. Fogelberg and Wm. Hughes of R. T. French Company, Shelley, Idaho, and to A. Potter, W. J. Weston, and E. Breitweiser of this Laboratory for material and assistance in the experiments reported.

LITERATURE CITED

1. Association of Official Agricultural Chemists, *Official and Tentative Methods of Analyses* (1945 ed.), p. 404.
2. Olson, R. L., and Harrington, W. O. Dehydrated mashed potatoes—a review, *AIC-297* (mimeo.), U. S. Department of Agriculture, Bureau of Agricultural and Industrial Chemistry, Western Regional Research Laboratory (1951).
3. McCready, R. M., Guggolz, J., Silviera, V., and Owens, H. S. Determination of starch and amylose in vegetables. *Anal. Chem.*, 22, 1156 (1950).

Antibiotics in Food Preservation. I. The Influence of Subtilin on the Thermal Resistance of Spores of Clostridium Botulinum and the Putrefactive Anaerobe 3679[a,b]

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(Manuscript received September 30, 1952)

A report covering results of a study designed to determine if subtilin in relatively low concentrations (3.5 to 14 p.p.m.) in a food would decrease the resistance to heat of spores of two important food spoilage bacteria. Temperatures employed were in the range of those commonly employed for processing low-acid foods. Times required at the various temperatures, to destroy 90% of the spores present in a food containing the various concentrations of subtilin, are compared. Results of the study indicate that spores of the Putrefactive Anaerobe 3679 or Clostridium botulinum are appreciably less resistant to heat when suspended in a food containing small amounts of subtilin than when suspended in a subtilin-free food. The effect of subtilin on resistance was consistent at all temperatures employed.

In recent years the possibility of using various antibiotics as food preservatives has engaged the attention of a number of investigators (*1, 2, 3, 4, 5, 6,* and others). No attempt will be made here to review published reports in detail. It is believed sufficient to point out wherein the objective of the study described differs from that of related studies conduced by other investigators. In reviewing published reports one comes to the conclusion that, generally speaking, the objective has been to find an antibiotic which when present in foods in relatively small amounts will inhibit development of spoilage bacteria capable of surviving extremely mild heat treatments [in the order of 5 to 10 minutes at 212° F. (100° C.)]. Though opinions which have been expressed (*1, 2, 4, 5, 6*) regarding the efficacy of a number of antibiotics in food preservation are somewhat contradictory, it would appear that the possibilities for using antibiotics solely as agents to inhibit development of spoilage bacteria, not killed by mild heat treatments, are not too encouraging. However, because results to date are very limited, any conclusion in this regard would certainly be premature.

The objective of the current study, a portion of which is described herein, has been to determine whether certain antibiotics present in foods in relatively small amounts would reduce the resistance of bacterial spores to heat, and if so, to what extent. The objective is based on the assumption that, if small amounts of an antibiotic would reduce the heat resistance of spores, it might be possible to reduce, accordingly, the severity of heat processes given certain food items. In other words, is it possible through the addition of an antibiotic or antibiotics to produce sterile foods by applying heat processes less severe than those currently employed? If so, it might allow the production of higher quality heat-processed foods, the keeping quality of which would not depend upon any amount of antibiotic remaining in the foods subsequent to their being heat processed.

This report deals only with findings relating to the influence of the antibiotic subtilin on the heat resistance of spores of *Clostridium botulinum* (strain 62A)[d] and the Putrefactive Anaerobe *3679*.

EXPERIMENTAL METHODS AND RESULTS

Production and handling of spore suspensions. All procedures involved in media preparation, in spore production, and

[a] Scientific Paper No. 1130, Washington Agricultural Experiment Stations, Pullman. Project No. 1101.

[b] Part of the work reported herein was done under contract with the U. S. Department of Agriculture and authorized by the Research and Marketing Act, 1946. The contract is being supervised by the Western Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry.

[c] Present address—American Can Company, Research Laboratories, San Francisco, California.

[d] Obtained in 1948 from Mr. C. T. Townsend, National Canners Association, San Francisco, California.

in estimation of spore concentrations were the same as those described elsewhere *(8)*. A liver broth medium was employed for production of spores of P. A. *3679*, and a beef heart medium for production of *C. botulinum* spores. A single suspension of spores of each organism was produced in sufficient quantity for the entire study covered by this report. The spore concentration of each of the two suspensions was estimated by the technique employing the thermoresistometer[a] *(7, 8)* for destroying vegetative cells and activating spores. The number of P. A. *3679* spores per ml. of the one suspension was estimated to be 73,000,000. This value was the average of counts obtained from five replicate determinations. The number of *C. botulinum* spores per ml. of the other suspension was estimated to be 85,000,000. Similarly, this value was the average of counts obtained from four replicate determinations. Subcultures from the diluted suspensions upon which all spore counts depended, were incubated 90 days at 85° F. (29.4° C.). For all subculturing, Yesair's medium as described by Wynne and Foster *(9)* was used.

Preparation and heating of food samples. A commercially prepared canned pea puree, to which was added various amounts of subtilin, was used throughout the study as the medium in which to suspend the spores for heat treatments. The subtilin employed for Experiment I (see Tables 1 and 2) was supplied by the Western Regional Research Laboratory, Albany, California; that employed for Experiments II and III was supplied by Chas. Pfizer and Co., Brooklyn, N. Y. The potency[b] of the WRRL preparation was 70% while that of the Pfizer preparation, was 57.5%.

In preparing material for the food samples, the appropriate amount of either preparation of subtilin was added to a given quantity of pea puree so as to give the desired subtitlin concentration in terms of parts of pure subtilin per million parts of puree (0.0, 3.5, 7.0, or 14.0 p.p.m.). This was accomplished by preparing a solution of the respective preparation and adding appropriate amounts of the solution to given volumes of pea puree. To assure uniform distribution of the subtilin, each subtilin-puree preparation was mixed in a Waring Blendor for 10 minutes. Care was taken to avoid greater than necessary dilution of the puree.

Stock spore suspensions prepared as described above were diluted with sterile distilled water so as to give the desired number of spores per 0.01 ml. of the final dilution. This final dilution also contained subtilin in a concentration of 0.0, 3.5, 7.0, or 14.0 p.p.m. as desired. This permitted mixing quantities of spore suspension and pea puree of the same subtilin concentration. Each inoculated food sample was prepared by adding 0.01 ml. of the appropriately diluted spore suspension and approximately twice this volume of pea puree to a thermoresistometer cup and mixing the suspension and puree with a sharpened inoculating needle. Each sample contained 7,300 P. A. *3679* spores or 42,500 *C. botulinum* spores and 0.0, 3.5, 7.0, or 14.0 p.p.m. subtilin.

Samples so prepared were subjected in the thermoresistometer to temperatures indicated in column 1 of Tables 1 and *2* for predetermined times. With the exception of control samples in Experiment I, inoculated with P. A. *3679* spores, six replicate samples were subjected to each time-temperature relationship employed. Twelve control P. A. *3679* inoculated samples were subjected to each time-temperature relationship employed in Experiment I. In each case an attempt was made to choose times such that the six samples (in the one case twelve) subjected to a given temperature for the longest time would be sterilized, while none of the six subjected to a given temperature for the shortest time would be sterilized. (The two blank spaces in Table *2* denote failures in this respect.) Between the longest and shortest times a number of other times were selected so that the 8 to 12 times employed increased from shortest to longest by a small but consistent interval. By so selecting the heating times, a number of the intermediate times employed with each temperature resulted in a number but not all of the six samples, subjected to a given temperature for each of these intermediate times, being sterilized. Consequently, from results obtained it was possible to calculate by methods described elsewhere *(8)* the most probable number of spores surviving a number of the time-temperature relationships employed. Knowing the initial number of spores per sample and the most probable number surviving a given time-temperature relationship, it was possible to calculate the time required at a given temperature to destroy 90% of the spores. This time is designated as the "D" value and as may be noted from Tables 1, *2*, and *3* has been used to express relative resistance of spores suspended in pea puree containing various amounts of subtilin.

Each food sample subjected to a designated time-temperature relationship was immediately thereafter ejected from the thermoresistometer into a tube of Yesair's pork infusion agar (approx. 20 ml.) which contained no subtilin. The tubes were allowed to remain undisturbed until the agar had solidified, sealed by adding approximately *2* ml. of warm paraffin-paraffin oil-vaseline mixture, and placed in an incubator thermostatically controlled at approximately 85° F. (29.4° C.). Each tube was examined periodically during incubation for development of bacterial colonies. From the record of these observations it was possible to calculate D values as described above. All values reported in this paper are for subcultures incubated 90 days.

TABLE 1

Calculated time (min.) for 90% destruction of P. A. 3679 spores subjected to the indicated temperatures while suspended in pureed peas containing the indicated concentrations of subtilin

Temp. °F.	D values for P. A. 3679 spores in peas containing subtilin			
	0.0 p.p.m.	3.5 p.p.m.	7.0 p.p.m.	14.0 p.p.m.
Exp. I				
240	5.43	3.74	2.97	2.18
250	1.75	1.07	0.844	0.622
260	0.430	0.288	0.226	0.180
270	0.102	0.0683	0.0540	0.0489
Exp. II				
240	5.45	3.34	2.91	2.62
250	1.57	1.01	0.884	0.753
260	0.428	0.247	0.234	0.194
270	0.0894	0.0632	0.0547	0.0570
Exp. III				
240	5.61	3.72	2.79	2.57
250	1.68	1.05	0.887	0.738
260	0.405	0.244	0.229	0.205
270	0.0920	0.0647	0.0621	0.0460

TABLE 2

Calculated time (min.) for 90% destruction of C. botulinum spores subjected to the indicated temperatures while suspended in pureed peas containing the indicated concentrations of subtilin

Temp. °F.	D values for *C. botulinum* spores in peas containing subtilin			
	0.0 p.p.m.	3.5 p.p.m.	7.0 p.p.m.	14.0 p.p.m.
Exp. I				
230	2.41	1.90	1.69	1.52
240	0.562	0.435	0.436	———
250	0.126	0.0985	0.0989	0.0941
260	———	0.0246	0.0228	0.0228
Exp. II				
230	2.37	1.74	1.89	1.55
240	0.520	0.480	0.359	0.340
250	0.133	0.0951	0.0846	0.0754
260	0.0318	0.0272	0.0233	0.0212
Exp. III				
230	2.37	1.90	1.62	1.50
240	0.537	0.395	0.318	0.292
250	0.123	0.0923	0.0885	0.0689
260	0.0307	0.0229	0.0255	0.0214

[a] The thermoresistometer used throughout this study was kindly loaned to us by Food Machinery and Chemical Corporation, San Jose, California.

[b] Potency values as given here are those furnished, with the subtilin preparations, by the Western Regional Research Laboratory and by Pfizer and Co., respectively. They were determined by microbiological assay.

TABLE 3

Average time (min.) for 90% destruction of P. A. 3679 and C. botulinum spores subjected to the indicated temperatures while suspended in pureed peas containing the indicated concentrations of subtilin

Organism and temp. (° F.)	Average D values for spores in peas containing subtilin			
	0.0 p.p.m.	3.5 p.p.m.	7.0 p.p.m.	14.0 p.p.m.
P. A. 3679				
240	5.50	3.60	2.89	2.46
250	1.67	1.04	0.872	0.704
260	0.421	0.260	0.230	0.193
270	0.0945	0.0654	0.0569	0.0506
C. botulinum				
230	2.38	1.85	1.73	1.52
240	0.540	0.437	0.371	0.316
250	0.127	0.0953	0.0907	0.0795
260	0.0313	0.0249	0.0239	0.0218

RESULTS AND DISCUSSION

The D values, obtained for P. A. 3679 spores heated while suspended in pea puree containing various amounts of subtilin and subcultured in a subtilin-free medium, appear in Table 1. Similarly D values obtained for *C. botulinum* appear in Table 2. Averages of D values obtained for spores of the two organisms in the 3 replicate experiments appear in Table 3. Thermal death time curves based on values in Table 3 for spores of P. A. 3679 suspended in subtilin-free puree and in puree containing 14.0 p.p.m. subtilin are plotted in Figure 1.

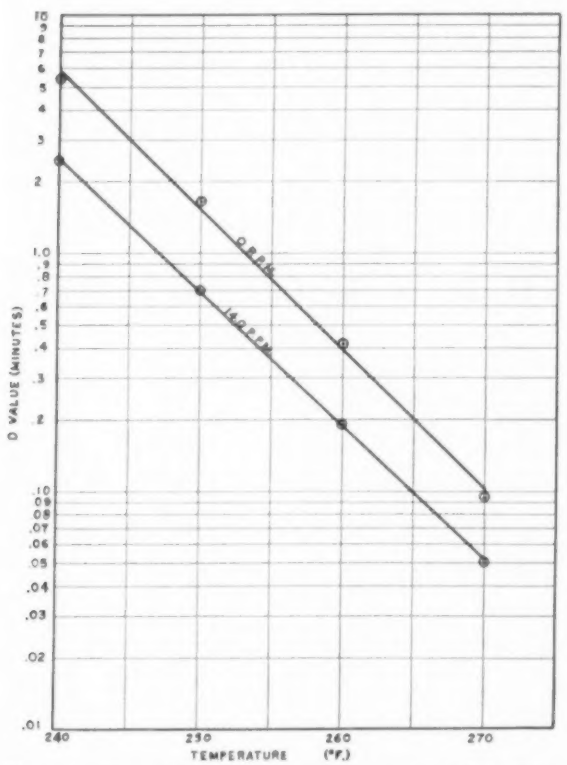

Figure 1. Thermal death time curves for spores of P. A. 3679.
Top curve. For spores heated while suspended in subtilin-free pea puree.
Bottom curve. For spores heated while suspended in pea puree containing 14.0 p.p.m. subtilin.

Corresponding thermal death-time curves for spores of *C. botulinum* are plotted in Figure 2. For the sake of clarity, thermal death-time curves for the spores heated while suspended in puree containing 3.5 or 7.0 p.p.m. subtilin were not included in the figures. However, examination of values in Table 3 will reveal that had these curves been plotted they would have fallen between those plotted and in positions in accordance with the concentrations of subtilin involved.

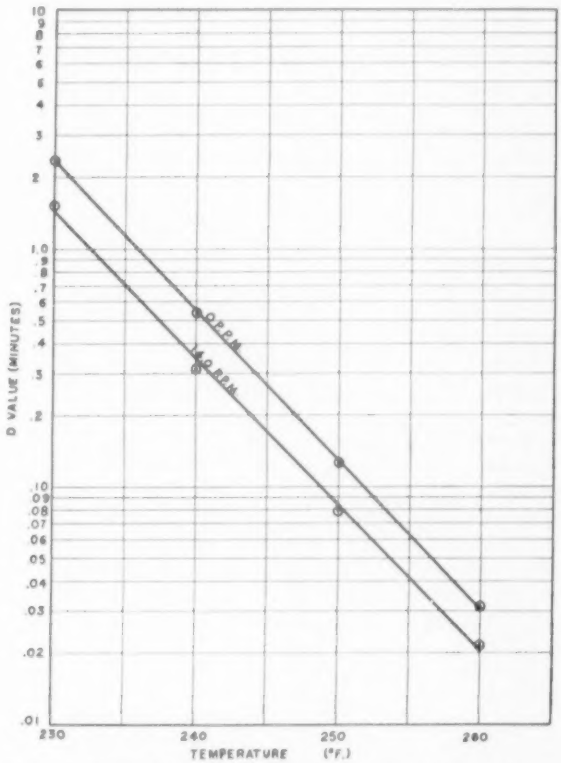

Figure 2. Thermal death time curves for spores of C. botulinum.
Top curve. For spores heated while suspended in subtilin-free pea puree.
Bottom curve. For spores heated while suspended in pea puree containing 14.0 p.p.m. subtilin.

As a result of our efforts to conserve space by presenting results only in summary form it may not be apparent from the foregoing that the values reported are based on results obtained from a large number of inoculated food samples. Each experiment involved the preparation, heating, subculturing, and observation of more than 2,000 food samples. Including samples involved in making spore counts, in conducting range-finding determinations, and in conducting the three replicate experiments, more than 10,000 samples were involved in all. These facts are mentioned in justification of the confidence which we place in the results obtained. It may be noted upon examination of Tables 1 and 2 that essentially the same results were obtained in each of the three replicate experiments. We feel that this is particularly noteworthy since Experiment I

was conducted by Mr. LeBlanc and Experiments II and III by Mr. Devlin almost a year later. Also, as was noted earlier, the subtilin employed in Experiment I was from a different source than that employed in Experiments II and III.

One might conclude from the results presented that subtilin as employed here materially reduced the resistance of spores of both P. A. 3679 and *C. botulinum* to heat. This reduction in resistance obtained regardless of temperature in the range employed. Before drawing definite conclusions with regard to the direct effect of small amounts of subtilin on resistance, it was necessary to examine the possibility that small amounts of subtilin carried into the subculture medium by the sample, inhibited germination of surviving spores or growth of vegetative cells arising from surviving spores. Subtilin carried into the subtilin-free subculture medium in this manner was diluted by the medium approximately 1,000 times.

A limited number of experiments were conducted to determine if quantities of subtilin in the subculture medium, equivalent to those carried over by food samples containing 14.0 p.p.m., would inhibit spore germination or growth of vegetative cells of the two organisms employed in studies described above. Results of these studies, though limited, indicated that these small quantities of subtilin (about 0.014 p.p.m.) did not detectably influence either spore germination or growth of vegetative cells of these organisms. There still remains the possibility, though it may be remote, that when spores are heated in the presence of subtilin, the subtilin is tenaciously adsorbed by the spores; and, even though the spores are transferred to a subtilin-free medium, the subtilin may be retained by the spores and thereby exert inhibitory effects. This postulates a mechanism of action of subtilin which has not been studied; but, if such a mechanism obtains it would probably, for all practical purposes, be just as effective in preventing bacterial development as if the action were truly lethal.

Whatever the mechanism of action of subtilin responsible for the observed reductions in resistance of spores to heat, we can conclude that the effects noted have been definite and readily reproducible. Summarizing further the data in Table 3, it is found that on the average the resistance of P. A. 3679 spores suspended in pea puree containing 14.0 p.p.m. of subtilin is only about 47% of the resistance of these spores suspended in subtilin-free puree. Similarly, the resistance of *C. botulinum* spores suspended in the puree containing 14.0 p.p.m. of subtilin is only about 63% of the resistance of these spores suspended in the subtilin-free puree.

It cannot be overemphasized that the results obtained are for spores of a single strain of each, P. A. 3679 and *C. botulinum*, suspended in only one food product. Before general conclusions can be drawn relative to the efficacy of subtilin in reducing bacterial spore resistance to heat, its effect on resistance of spores of many species and of many strains of these species, e.g., *C. botulinum*, will have to be carefully determined. Further, if such indicated laboratory studies yield results comparable to those reported here, investigations in which practical operating conditions are closely simulated will necessarily have to precede any recommendations for the commercial use of subtilin as a food preservative. These facts are pointed out to emphasize that the results presented are in no way intended to infer the use in the near future of subtilin as a food preservative. Such use may eventually come about, but certainly it can not until far more research has been completed. Studies are now in progress involving several different species of bacteria important in food spoilage, including a number of strains of *C. botulinum*. In addition, the efficacy of a number of other antibiotics is under study.

SUMMARY

Results of the study reported herein indicate that spores of P. A. 3679 or *C. botulinum* are appreciably less resistant to heat when suspended in a food containing small amounts of subtilin than when suspended in a subtilin-free food. The results reported are for spores of only one strain of each organism suspended in one food product, pea puree. However, it is felt that the practical implications of this limited study are such as to emphasize the need for its extension to include a large number of strains of virtually all of the more important heat resistant food spoilage organisms in a wide variety of food items. Until such an extended study has been completed, definite conclusions relative to the possible commercial application of subtilin as a food preservative adjunct cannot be drawn.[g] The same may be said with respect to any other antibiotic.

LITERATURE CITED

1. Adams, A. T., Ayers, J. C., and Tischer, R. G. The effect of subtilin in preventing spoilage of comminuted beef. *Food Technol.*, **5**, 82 (1951).
2. Andersen, A. A., and Michener, H. D. Preservation of foods with antibiotics. I. Preservation of vegetables with subtilin and mild heat treatment. *Food Technol.*, **4**, 188 (1950).
3. Andersen, A. A., and Michener, H. D. Effect of subtilin on bacterial spores. *Bact. Proc.*, 28 (1950).
4. Burroughs, J. D., and Wheaton, I. E. Studies on the preservative action of antibiotics in processed foods. *Canner*, **112**, 50 (1951).
5. Cameron, E. J., and Bohrer, C. W. Food preservation with antibiotics: The problem of proof. *Food Technol.*, **5**, 340 (1951).
6. Curran, H. R., and Evans, F. R. The activity of penicillin in relation to bacterial spores and the preservation of milk. *J. Bact.*, **52**, 89 (1946).
7. Stumbo, C. R. A technique for studying resistance of bacterial spores to temperatures in the higher range. *Food Technol.*, **2**, 228 (1948).
8. Stumbo, C. R., Murphy, J. R., and Cochran, Jeanne. Nature of thermal death time curves for P. A. 3679 and *Clostridium botulinum*. *Food Technol.*, **4**, 321 (1950).
9. Wynne, E. S., and Foster, J. W. Physiological studies on spore germination with special reference to *Clostridium botulinum*. I. Development of quantitative method. *J. Bact.*, **55**, 61 (1948).

[g] Practical use of these agents in foods is not permitted at the present time.

A Comparison of the Triangular and Two-Sample Taste-Test Methods

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(Manuscript received September 12, 1952)

In triangular taste tests requiring selection of the odd sample, results have at times indicated that the taste differences may have been somewhat obscured by the test procedure itself. Therefore experimental parallel taste tests (using differing concentrations of quinine or dextrose in aqueous solution) were carried out to compare odd sample selection by the triangular test with judgment of taste quality intensity by the two-sample procedure. The two-sample test results reflected discrimination of higher statistical significance than did those of the triangular tests.

Quality judgments made within these experimental triangular tests also achieved higher significance than the corresponding odd-sample selections. In fact, there was little, if any, tendency for tasters correctly selecting the odd sample to be more correct than the others in their quality judgments.

These findings demonstrate that assessment of taste-test methods is advisable to assure their effectiveness under the given conditions.

Principles and procedures of objective taste-testing applicable to beer have been treated in our Laboratories' journal[a] over the years in a number of articles, notably those by Metzner *(9)*, Bengtsson and Helm *(3)*, and Helm and Trolle *(6)*. These papers gave particularly detailed treatment to the use of statistical techniques in connection with the 2-sample and triangular taste-testing procedures, and these procedures have since been widely employed in the testing of foods and beverages. The triangular test, in which the taster is required to designate the odd sample of a group of 3 samples, 2 being alike and one different, found especially extensive application following its use by Gray, Stone and Atkin *(4)* at these laboratories in a study of the influence of oxidation on aroma and flavor of bottled beer.

Frequently, however, the triangular testing has reflected much less taste discrimination than would be expected. For example, when samples were compared by aroma alone the percentage of correct choices obtained was often greater than when no attempt was made to separate odor and taste impressions. In view of such considerations, it was natural to question whether the taste-test procedure itself might cause taste differences to be less noticeable; the literature, however, contains practically no data comparing taste tests on the basis of actual trials.

Helm and Trolle *(6)* did compare the triangular and 2-sample procedures, but primarily for the purpose of selecting a panel of "expert" beer tasters. The percentages of correct identifications were practically the same, but owing to the specially prepared samples used, were so high as to obscure any possible superiority of one test over the other. Such an experiment would probably show any inequality more clearly with materials of small, although still demonstrably perceptible, taste difference. This requirement, it was felt, could most conveniently be attained by use of solutions of pure substances of relatively simple taste character, the concentrations being adjusted, insofar as practicable, to give triangular test results corresponding, for the panel sizes to be employed, to between 1% and 5% levels of significance (see footnotes b and c to page 186).

[a] *Wallerstein Laboratories Communications.*

METHODS AND MATERIALS

Among the various taste qualities making up beer or ale flavor, two of greatest interest are bitterness and sweetness (or lack of sweetness, which may be termed dryness); hence pure substances having these taste qualities were employed, in aqueous solution, quinine sulfate for the bitterness tests and dextrose for the sweetness tests. The pairs of concentrations were decided on after preliminary triangular testing indicated their taste differences to be approximately of the desired significance level.

In the first full-scale bitterness trial, with solutions containing 0.0075% and 0.0050% respectively of quinine sulfate, there were more correct selections in the triangular test than had been anticipated. A second trial was accordingly made with solutions containing 0.0060% and 0.0050% quinine sulfate, respectively.

In the sweetness comparison, the solutions contained 1.19% and 1.40%, respectively, of dextrose.

Each pair of solutions was presented to the taste panel members for comparison by both the triangular test and the 2-sample test.

In the triangular bitterness tests each taster received 3 glasses, 2 containing the same quinine solution and the third a different quinine solution, from which he was required to select the odd sample. He was required also to state whether he considered the sample selected as odd to be more bitter or less bitter than the two he judged to be alike. The 6 presentation orders: LHH, HLH, HHL, HLL, LHL, LLH (L = lower concentration, H = higher) were randomly distributed among the tasters.

In the 2-sample tests for bitterness each taster was required to select from 2 glasses the one containing the more bitter of 2 solutions. The 2 orders of presentation HL and LH, were alternated among the test participants. With one pair of solutions (quinine sulfate at 0.0050% and 0.0060% concentrations) each taster received the opposite presentation on another day, but without knowledge of the duplication.

Sweetness comparisons were made in substantially the same manner with dextrose solutions: in the triangular test the taster noted whether the sample selected as odd was considered sweeter or less sweet than the others and in the 2-sample tests designated which sample was sweeter. The latter tests were given twice in succession at the same sitting, the 4 arrangements (LH-LH, LH-HL, HL-HL, HL-LH) being randomized.

All the tests were carried out in a room constructed especially for our laboratories' taste-testing work, and precautions were taken toward securing independent selections. When taking the test, the tasters sat at a table subdivided into booths which prevented each taster from seeing either the samples of the others or the work area where samples were prepared. Ruby-colored glasses were used so that color or clarity differences, if present, would be obscured. The possibility of bias due to codes, pointed out by Harrison and Elder *(5)* was avoided by eliminating the tasters' need to refer to code markings. Instead the tasters had only to affix a spring clip to the appropriate glass. In the tri-

TABLE 1
Taste-test results by triangular and two-sample procedures

	No. of correct selections	No. of incorrect selections	Total	Percentage of correct selections		No. of correct selections in excess of chance expectancy, in σ units
				Obtained	Expected	
First bitterness test (Quinine sulfate solutions 0.0050% vs. 0.0075%)						
Triangular test (for selection of odd sample)	25	25	50	50%	33⅓%	2.50**
Two-sample test (for selection of more bitter sample)	34	4	38	89%	50%	4.87***
Second bitterness test (Quinine sulfate solutions 0.0050% vs. 0.0060%)						
Triangular test (for selection of odd sample)	21	25	46	46%	33⅓%	1.77*
Two-sample test (for selection of more bitter sample)						
Trial 1	47	17	64	73%	50%	3.75***
Trial 2	40	14	54	74%	50%	3.54***
Sweetness test (Dextrose solutions 1.19% vs. 1.40%)						
Triangular test (for selection of odd sample)	21	24	45	47%	33⅓%	1.90*
Two-sample test (for selection of sweeter sample)						
Trial 1	33	12	45	73%	50%	3.13***
Trial 2	31	14	45	69%	50%	2.54**

angular test this was the sample selected as odd, and the taster had merely to check on a ballot whether it was considered more bitter or less bitter (or more sweet or less sweet) than the others. Inconspicuous code marks on the bottom of the glasses identified them to the personnel conducting the tests.

DISCUSSION OF RESULTS

Odd sample selection vs. 2-sample test. The numbers, or even the proportions, of correct responses in the 2-sample tests and of correct odd sample selections in the corresponding triangular tests, although given in Table 1, should not be directly compared in the evaluation of the 2 test methods, since the chance expectation of ⅓ that a taster will choose the odd sample correctly in the triangular test is smaller than the chance expectation of ½ that he will correctly select the more bitter (or more sweet) sample in the 2-sample test. The numbers of correct selections in excess of chance expectation are accordingly given also in terms of standard deviations or σ units,[b] as with panels that are fairly large and of about the same size, equal deviations in σ units correspond closely to equal probabilities of occurrence of the results by chance, the greater the deviation, the smaller being the probability that the results reflect chance variation and the greater being the significance attached to the tasters' discrimination.[c]

The tabulation of the deviations in σ units shows that in all 3 experiments more significant results were obtained in selection of the more bitter (or more sweet) sample in the 2-sample test than in selection of the odd sample in the triangular test; thus the 2-sample test gave more clear-cut evidence of a taste difference.

Odd sample selection and quality differentiation within the triangular test. The shortcomings of the triangular test for selection of the odd sample are further revealed by internal evidence of the triangular test results themselves. As mentioned above, besides being asked to select the odd sample in the triangular test, each taster was asked to state whether the sample so selected was considered more bitter or less bitter (or more sweet or less sweet) than the remaining two.

In the procedure described by Bengtsson *(1)* such supplementary statements would be taken into consideration only when made by tasters who selected the odd sample correctly. The experiments described herein, however, dealt with solutions of known concentrations, so that regardless of the tasters' correctness in selection of the odd sample, it was possible to tell whether its quality designation as more bitter or less bitter (or more sweet or less sweet) correctly reflected whether the solution was of the higher or lower concentration. On this basis these suplementary designations could be treated as 2-sample test results unrelated to success or failure in the selection of the odd sample.

It can be seen from Table 2 that in all 3 tests the proportion of correct quality designations is significantly greater than the 50% expected by chance, with little difference, on the whole, between the tasters who were correct in their selection of the odd sample and those who were incorrect. The conclusion seems justified, therefore, that the latter showed a significant degree of ability to discriminate which was not made manifest in the selection of the odd sample in the triangular test.

That the triangular test should be found relatively less sensitive than the 2-sample test in these experiments probably reflects in large part inherent limitations of flavor perception. The impression of a flavor which a taster retains as he proceeeds from one sample to another can apparently be appreciably influenced, as by the order in which the samples are presented and the number of samples. Also the substance tasted may partially desensitize the taste organs. At any rate, as the number

[b] Number of σ units in excess of chance expectation $= \dfrac{n - Np}{\sqrt{Npq}}$

where
N = total number of tasters
n = actual number of correct choices
p = probability of a correct choice by chance
q = probability of an incorrect choice by chance.

The term Np in the numerator is the number of correct selections expected by chance. The denominator, $\sqrt{Npq}$, gives the number of choices equal to σ and is taken as positive.

[c] The following tabulates approximate values of the probability that an equal or greater excess of σ units above chance expectation would occur merely by chance *(11)*.

Number of σ units above chance expectation	Probability	Significance designation
1.65 to 2.33	0.05 to 0.01	* (significant)
2.33 to 3.09	0.01 to 0.001	** (highly significant)
3.09 or more	0.001 or less	*** (very highly significant)

TABLE 2

Taste quality intensity designations (more bitter or less bitter, or more sweet or less sweet) in triangular test

	No. correct	No. incorrect	Total	Percent correct		No. correct in excess of chance expectancy in σ units
				Obtained	Expected	
First bitterness test (Quinine sulfate solutions 0.0050% vs. 0.0075%)						
Quality designations by tasters correct in odd sample selection	24	1	25	96%	50%	4.60***
Quality designations by tasters incorrect in odd sample selection	20	5	25	80%	50%	3.00**
Total	44	6	50	88%	50%	5.37***
Second bitterness test (Quinine sulfate solutions 0.0050% vs. 0.0060%)						
Quality designations by tasters correct in odd sample selection	15	6	21	71%	50%	1.97*
Quality designations by tasters incorrect in odd sample selection	17	7	24	71%	50%	2.04*
Total	32	13	45[a]	71%	50%	2.83**
Sweetness test (Dextrose solutions 1.19% vs. 1.40%)						
Quality designations by tasters correct in odd sample selection	15	6	21	71%	50%	1.97*
Quality designations by tasters incorrect in odd sample selection	21	5	26	81%	50%	3.14***
Total	36	11	47[b]	77%	50%	3.65***

(*) (**) (***) See footnotes b and c to page 186.

[a] One taster counted in Table 1 did not make a bitterness designation and is not included here.

[b] Two tasters counted here did not participate in the two-sample test and are not included in Table 1.

of samples per test is increased, the taster is likely to become more confused in his comparison of one sample with those preceding. While these experiments were limited to simple substances and insofar as possible to 2 taste characteristics, tests of more complex materials have led other workers also to express the opinion that presentation of only 2 samples allows the most critical comparison. An example may be found in the report by MacLean and Wickens *(8)* of their use of taste tests in ranking 6 cacaos. The detailed statistical treatment recently given by Scheffe *(10)* to test designs in which a number of samples are judged two at a time further illustrates the usefulness of the 2-sample technique, even for multi-sample comparison.

When triangular tests are used, it appears that discrimination may sometimes be better demonstrated by inclusion, where feasible, of a quality question (such as whether the sample chosen as odd is more bitter or less bitter, or more pleasing or less pleasing) and by analysis of the answers given not only by the tasters who select the odd sample correctly but also by those who do not. It is of interest in this connection to note that this possibility of taking advantage of quality designations by those who select incorrectly is lost in the type of 4-sample test wherein the taster is required to arrange in pairs 2 samples of each of 2 products. This test has been referred to by Lockhart *(7)* as equivalent statistically to the triangular test.

A possible alternative to the triangular test is the two-sample design for beer testing described by Bengtsson *(2)* which may be used as a test for both difference and preference and requires each taster to take a 2-sample preference test twice. Should the results not show an over-all preference, a detectable taste difference might nevertheless be revealed if significantly more tasters were consistent in their choice than would be expected by chance. Such consistency would be taken to indicate that the beers were different, one group within the panel preferring one beer, and another group preferring the other beer.

This design could be extended to give the 2-sample test 4 times to each taster, the 6 different presentation arrangements possible being randomized as shown below; this has the advantage of permitting separate evaluation of the consistency of choice of the entire panel for each presentation order.

Six Presentation Arrangements of Two Orders in Four Tests

	1	2	3	4	5	6
Test I	AB	BA	AB	BA	AB	BA
Test II	AB	BA	BA	AB	BA	AB
Test III	BA	AB	AB	BA	BA	AB
Test IV	BA	AB	BA	AB	AB	BA

The results obtained in the above experiments with simple substances must of course be applied with caution to complex materials such as beer or ale. Nevertheless, the consistent difference in effectiveness found between odd sample selection in the triangular test and quality designation in either the two-sample or the triangular test, in each of the three experiments described, suggests that any decision as to the taste test design to be employed in a given situation requires careful preliminary investigation. The effectiveness of the procedure with the specific materials and under the specific conditions involved must be taken into account. This may be particularly important when, as is usual in most tests, the taste differences are not expected to be very large. Specifically, where triangular tests are contemplated, consideration should be given to whether triangular test modifications or use of other designs may more accurately reflect the panel's ability to discriminate taste differences.

LITERATURE CITED

1. Bengtsson, K. Provsmakning som analysmetod. Statistisk behandling av resultaten. *Svenska Bryggarefören. Månadsblad*, **58**, 59 (1943).
2. Bengtsson, K. Innebörden i statistiskt utslag vid provsmakning. *Svensk Bryggeritidskrift*, **61**, 253 (1946).
3. Bengtsson, K., and Helm, E. Principles of taste testing. *Wallerstein Lab. Comm.*, **9**, 171 (1946).
4. Gray, P. P., Stone, I., and Atkin, L. Systematic study of the influence of oxidation on beer flavor. *Wallerstein Lab. Comm.*, **10**, 183 (1947).
5. Harrison, S., and Elder, L. W. Some applications of statistics to laboratory taste testing. *Food Technol.*, **4**, 434 (1950).
6. Helm, E., and Trolle, B. Selection of a taste panel. *Wallerstein Lab. Comm.*, **9**, 181 (1946).
7. Lockhart, E. E. Binomial systems and organoleptic analysis. *Food Technol.*, **5**, 428 (1951).
8. MacLean, J. A. R., and Wickens, R. Application of an incomplete block design to the assessment of quality in cacao. *Nature*, **168**, 434 (1951).
9. Metzner, C. A. Investigation of odor and taste. Psychological principles. *Wallerstein Lab. Comm.*, **6**, 5 (1943).
10. Scheffe, H. An analysis of variance for paired comparisons. (Presented at American Society for Quality Control, Seminar, Princeton, N. J., Dec. 8, 1951).
11. Yule, G. U., and Kendall, M. G. *An Introduction to the Theory of Statistics*. 1950, Hafner Publishing Co., New York.

Notes

On Plank's Rational Method of Grading Food Quality

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Numerical grading or scoring systems are continually used in sensory tests of food, but few writers have attempted to discuss the underlying rationale. An apparent exception is R. P. Plank to whose "Rational Methods for Grading Food Quality" *(4, 5)* favourable reference continues to be made (e.g. *1, 2, 3, 6*). Plank's arguments, however, involve certain unresolved difficulties or errors and it may be worthwhile to draw attention to them here.

Plank introduces three concepts as follows: (a) descriptive terms running from "perfect" to "unacceptable," (b) a "quality-percent" varying from 0% to 100%, and (c) numerical grades, from 0 to 10.

However, as far as one can see Plank does not give these three concepts separate identities. Sometimes grades (or "Noten," *4*) appear equivalent to the descriptive terms, but a number of graphs are also given on which quality-percent and the descriptive terms are plotted together on one axis, against the grades on the other. More generally, Plank's grades seem synonymous with his descriptive terms and with his quality-percent. Naturally enough, Plank's chosen grading system gives a straight line when plotted against his quality-percent (Figure 1 in each paper) whilst for grading systems other than his own "the line correlating grade and quality deviates very much from the desired straight line" *(5)*. Plank's criticism of other people's grading systems seems therefore to arise solely from his own confused verbal definitions.

More important than this confusion is Plank's apparent assumption that quality has already been quantitatively measured. Thus, "the fundamental supposition of any rational grading is that the number expressing the grade be proportional to the quality of the property to be measured" *(5)*. Or again, "an equal difference in grade numbers must correspond with an equal difference in quality." This assumes not only that it is already known what "an equal difference in quality" means and, presumably, that this meaning has been agreed to by different investigators, but also that such a state of affairs is both possible and desirable. That, however, is just the problem at issue.

Plank does not discuss how his concept of "quality" could be observed even qualitatively. Quantitatively, he considers that "it is reasonable to assume that the difference in quality between good and fair is equal to that between fair and poor" *(5)*. But neither the terms "good," "fair," etc. nor the conditions under which this "equality" is to hold are defined, nor is a general principle given by which differentiation could in fact be made. The statement, therefore, can neither be verified nor disproved.

The failure to give precision to the concept of "quality" appears in another form in the later sections of Plank's papers, where he defines an "integral grade" of quality as the sum of numerical assessments of different factors (i.e. odour, flavour, appearance, fat and mineral content, bacterial loads, etc.) variously weighted. Now Plank's account does not seem to allow for the direct observation of whatever it is that this "integral grade" might be supposed to represent or measure, so that again one cannot verify whether or not the integral grade is in any sense true or correct.

Lesser queries may occur to the readers of Plank's papers. For example, there is the fact that in making any measurements—of length let us say—one decides beforehand to measure only to the nearest inch, half-inch, or whatever it may be. On the other hand, there will also be those "errors of measurement" that become apparent in considering the reliability (as opposed to the sensitivity) of one's measurements. Should these two concepts be confused, as Plank seems to do?

Further comment on Plank's approach to the rationale of numerical scoring scales can hardly be made without introducing ideas not mentioned by him. Enough has perhaps been said here to indicate the paradoxical position of the subject when it is recalled that Plank was practically the only contemporary reference on scoring given in the review of the literature for the recent conference on "Sensory methods for measuring differences in food quality" *(6)*.

This note has arisen out of work carried out on behalf of the Department of Scientific and Industrial Research (Food Investigation Organisation).

December 1, 1952.

LITERATURE CITED

1. Bate-Smith, E. C. Organoleptic tests in the food industry. *J. Soc. Chem. Ind.*, **68**, 179 (1949).
2. Gutschmidt, J. Über die organoleptische Bewertung von Lebensmitteln mit Hilfe des Karlsruher Bewertungsschemas. *Z. für Lebensmittelkunde,-Wirtschaft und Recht*, **47**, 244 (1951).
3. Jakobsen, F. Rational grading of food quality. *Food Technol.*, **3**, 252 (1949).
4. Plank, R. Über die Wahl eines Bewertungschemas für die Qualitäts-Prüfung von Gefriererzeugnissen. *Vorratspflege u. Lebensmittelforch.*, **6**, 143 (1943).
5. Plank, R. A rational method for grading food quality. *Food Technol.*, **2**, 241 (1948).
6. Sensory methods for measuring differences in food quality. Review of the literature and proceedings of the conference, 1951. *Agriculture Information Bull.*, No. 34, U. S. Dept. of Agriculture, Washington, D. C.

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Abstracts

(Continued from page 22 preceding technical papers)

Glycollic aldehyde and triose phosphate condense in the presence of an aldolase prepn. from peas, to give D-xylulose. The metabolism of pentoses is discussed.

Structure of glycogens and amylopectins. I. Enzymatic determination of chain length.

Illingworth, B., Larner, J., and Cori, G. T. *J. Biol. Chem., 199*, 631-51 (1952).

Using the enzyme amylo-1, 6-glucosidase, the percent of end groups found on amylopectin varied from 5.9 to 4.1. The av. chain length for potato amylopectin was 22. From enzymatic degradation it was also concluded amylopectin can be represented by a multibranched or tree-like structure.

Building proteins.

Sci. American, 187, 44, November, 1952.

Attention is called to a report to the American Inst. of Biol. Sciences on the reproduction of tobacco mosaic virus from nitrogen of ammonia instead of amino acids.

New amino-acids in young apple fruits.

Hulme, A. C., and Arthington, W. *Nature, 170*, 659-60 (1952).

Four ninhydrin reacting substances were obtained in exts. of Worcester Pearmain apples, which were not attributable to any of the common amino acids. The identification of two of these is described in this paper. The first is a pyrrolidine compd. giving a violet ninhydrin reaction; the second was identified as piperidine-2-carboxylic acid.

Exogenous emulsifiers and fat absorption.

Tidwell, H. C., and Nagler, M. E. *Proc. Soc. Exptl. Biol. Med., 81*, 12-15 (1952).

As detd. by changes in the blood fat levels and by recovery of fat from the intestine after an absorptive period, the rate of fat absorption in normal, orally fed rats appears to be unaffected by 6 or 20% supplements of a number of exogenous emulsifiers. The lack of changes in the degree of fat splitting and intestinal motility which could affect fat absorption are in complete agreement with the above finding. The action of lecithin in promoting fat absorption seems best explained by other than its emulsifying action.

The portal transport of absorbed fatty acids.

Kiyasu, J. Y., Bloom, B., and Chaikoff, I. F. *J. Biol. Chem., 199*, 415-19 (1952).

After administrating C^{14} labeled fatty acids to rats it was found that short chain fatty acids were transported mainly by the portal pathway and long chain, satd. fatty acids by the lymph.

Experiments in the treatment of some haemorrhagic conditions with solutions of pectin and vitamin C.

Mondejar Del Rio, A. *Medicamenta, 17*, 77-8 (1952); *Nutrition Abstracts, Revs., 22*, 235-6 (1952).

The use of pectin and vitamin C in controlling haemorrhage is briefly described and the use of the two together on 241 patients is reported. In from 75 to 80%, of 225 with haemoptysis, haematemesis or melaena, benefit was obtained but little or no good result was seen in haematuria, haemophilia and other haemorrhagic conditions.

Decreased x-ray sensitivity of mice following the administration of ethanol.

Cole, L. J., and Ellis, M. E. *Am. J. Physiol., 170*, 724-9 (1952).

Single preirradiation intraperitoneal injection of 1.25–25.0% ethanol per 100 g. body wt. reduced mortality of mice exposed to mid-lethal and supralethal x-irradiation. The LD_{50} for control mice was about 620r; for treated mice, 814r.

Observations on the acute toxicity of two chlorinated phenols.

Joseph, J. M. *J. Am. Pharm. Assoc., 61*, 595-6 (1952).

Acute toxicity studies on methyl chlorothymol and *p*-chloro-*m*-xylenol indicated low toxicity, which is rarely observed with chlorinated phenolic compds. The MLD and the LD_{50} of methyl

(Continued on page 30)

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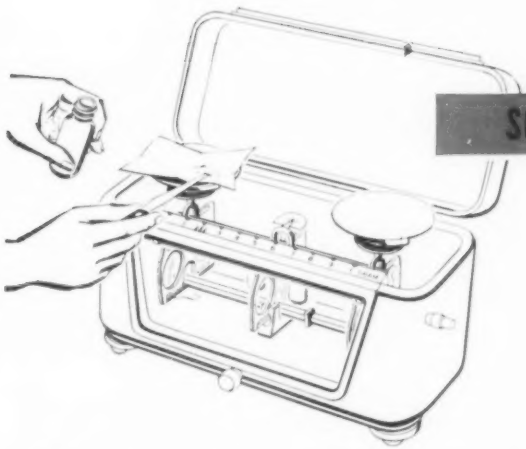

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DIAMOND CRYSTAL SALT with Antioxidant

Abstracts

(Continued from page 26)

chlorothymol for mice were both found to be 0.78 g. The toxicity of *p*-chloro-*m*-xylenol was found to be almost four times less than that of methyl chlorothymol.

The physical toxicity of chemicals. III. A systematic treatment of physical toxicity in aqueous solutions.

McGowan, J. C. *J. Applied Chem., 2,* 651-8 (1952).

The factors influencing the toxicity of a physically-toxic org. compd. in different biol. tests are discussed. Toxic concns. in aq. solns. for 26 sets of biol. expts. have been collected from the literature, arranged under the names of the 269 compds. listed in alphabetical order, and compared with the toxic concns. calcd. by means of the equation previously given (in Part II). 36 references.

Radioactive sugars.

Mfg. Chemist, 23, 413-15 (1952).

The prepn. by the U. S. Natl. Bureau of Standards of a sugar with a labelled carbon atom at a specific point within the mol. is described. The study of the cyanohydrin synthesis in prepn. of labelled glucose is discussed, emphasizing the reduction of the sugar acid lactone to the sugar. These materials should prove helpful in studying such problems as the role of lactose in nutrition, and the action of enzymes in living organisms.

NUTRITION

Biochemical evidence of nutritional status.

Lowry, O. H. *Physiol. Revs., 32,* 431-48 (1952).

An attempt is made to illustrate the biochem. possibilities of detg. the evidence of nutritional status using ascorbic acid, thiamin and riboflavin. A major purpose of the review is to stress the significance of tissue concns. of the nutrients and indicate a) how the tissue concns. relate to performance, and b) how these tissue levels are interrelated with intake excretion, blood levels and so forth.

Obesity is now number one nutritional problem.

Science News Letter, 62, 408 (1952).

Obesity has replaced vitamin deficiency diseases as primary nutritional problem in the U. S. One-fourth of the adult population is afflicted with this condition which is associated with diabetes, cirrhosis of the liver, cardiovascular disease, hernia, gall bladder disease and some forms of cancer and arthritis.

Average American eats 12% more than pre-war.

Science News Letter, 62, 388 (1952).

The av. American consumes 12% more food now than he did in pre-war years. However, he has not increased his intake of calories, he eats less starchy material, the same amt. of vitamin A and a little more vitamin C. In terms of food, he eats fewer potatoes and grain products, but more meats, citrus fruits, tomatoes, leafy green and yellow vegetables.

Food allergy with special reference to corn and refined corn derivatives.

Bernton, H. S. *Ann. Int. Med., 36,* 177-85 (1952); *Nutrition Abstracts Revs., 22,* 247 (1952).

Phosphorus compounds in nutrition and in industry.

Hart, E. B. *J. Am. Dietetic Assoc., 28,* 1036-8 (1952).

The recent articles in Consumers' Research Bull. 29:14 (March) 1952 condemning phosphates in foods is refuted.

Starch in infant feeding.

Lust, M. *Schweiz. med. Wochenschr., 82,* 417-18 (1952); *Nutrition Abstracts Revs., 22,* 207 (1952).

The use of starch in the feeding of infants is discussed with reference to the disadvantages of most cereal starches, which contain up to 10% of protein. Rice starch is considered the most suitable, as it is almost pure starch. Heated suspensions of

(Continued on page 34)

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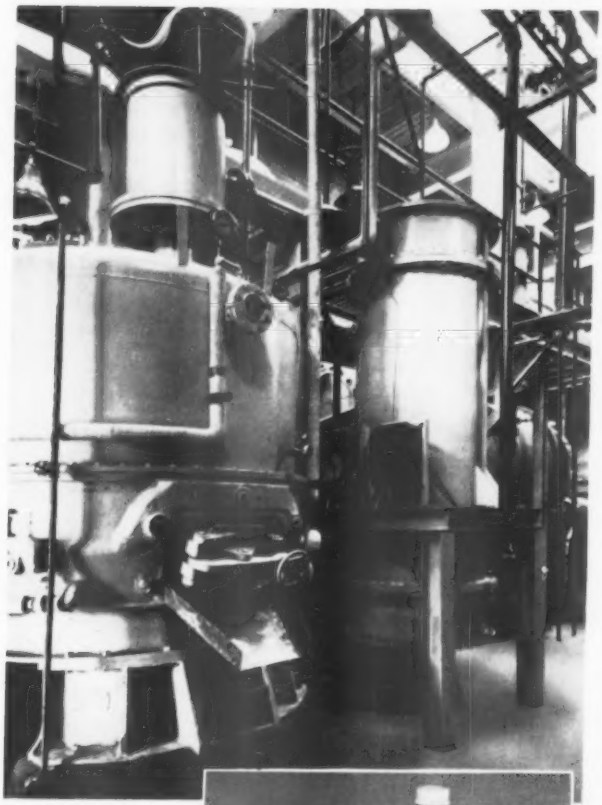

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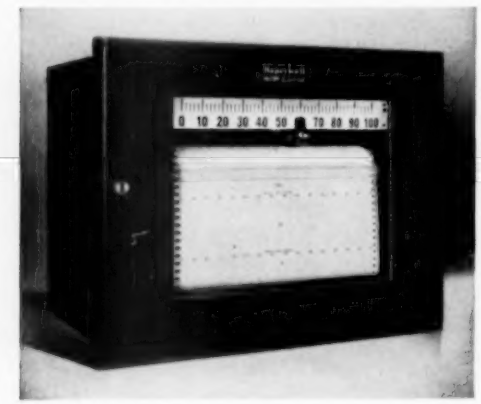

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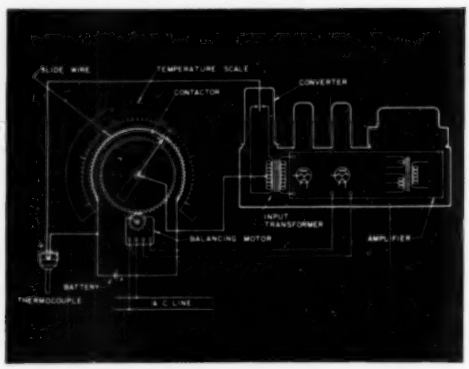

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Abstracts

(Continued from page 30)

starch yielded a colloidal soln. which aided digestion. Starch is held to be preferable to sugar for adding to cow's milk in infant feeding.

ENGINEERING AND PLANT EQUIPMENT

Blower and fan costs.

DENZLER, R. E. *Chem. Eng., 59,* 130-4 (1952).

Cost information is presented for three basic types of equipment: Axial flow propeller fans and blowers; radial flow centrifugal fans and blowers; and positive rotary blowers, gas pumps and compressors. Graphical plots are shown for standard conditions and costs. The text offers addnl. cost information on equipment extras.

FOOD AND FOOD TECHNOLOGY

Lipid binding in doughs. Effects of dough ingredients.

MECHAM, D. K., AND WEINSTEIN, N. E. *Cereal Chem., 29,* 448 (1952).

Much of the ether-extractable lipid of flours becomes "bound" when the flours are wetted or doughed. These earlier observations were largely restricted to flour-water doughs; the effects of some other bread dough ingredients at levels in the range used in baking have now been detd. Salt decreases lipid binding in doughs, both of total lipid and of phospholipid, to 20 to 40% less than that occurring in the absence of salt. A "softner" of the polyoxyethylene stearate type had somewhat similar effects. Shortening (lard) appeared to decrease phospholipid binding slightly, but did not affect total lipid binding appreciably. Other bread ingredients had no detectable effects. The lipid contents of glutens, washed out in salt solns., were lower than those washed out in water, paralleling the observations on lipid binding in doughs.

Improvement of the dietary value of wheat flour by different amino acids.

VOLET, B. *Thesis, Univ. Lausanne,* 9-38 (1951); *Nutrition Abstracts Revs., 22,* 164 (1952).

The essential amino-acids in which wheat flours are deficient are, in decreasing order, lysine, methionine, threonine, histidine, valine and tryptophan. Attempts were made to improve the flours by addn. of individual amino-acids, or of proteins such as gelatin and casein, which would supply some of the missing acids. On a basal diet of brown flour (whole) and 1.5% salts, the av. daily wt. increase for a group of 6 rats of initial wt. 40 g., during 8 weeks, was 1.18 g. Addn. of 5%, gelatin increased this value to 1.80 g. Addn. of 4.3% glycine, a non-essential amino-acid had little effect on the wt. increase (1.24 g.). The wt. changes for addns. of other amino acids are given.

Vegetable oils freeze up.

Chem. Week, 54-9, November 1, 1952.

A discussion of the market in frozen desserts contg. vegetable fat rather than butterfat. In Texas, where the frozen oil dessert was developed, cotton seed oil is used primarily. In Illinois and Missouri, coconut oil is preferred. Soybean processors are also trying to promote the use of soybean oil. At the moment the product has practically no official acceptance. The Food and Drug Administration will not allow its makers to use the name "ice cream" further, say any product made in the semblance of ice cream is adulterated. There are no Federal Standards for the new product. The Federal policy thus restricts sales to within the borders of the state where made.

The case against mineral oil.

BECKER, G. L. *Am. J. Digestive Diseases, 19,* 344-7 (1952).

Mineral oil and its emulsions should not be used internally because it alters normal physiology of evacuation, acts to increase ano-rectal infection; absorbed into body in quantities up to 60% it interferes with utilization and retention of calcium and phosphorus, produces wt. loss, etc.

(Continued on page 36)

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FOOD TECHNOLOGY, INC.

Abstracts

(Continued from page 34)

Comparative evaluation of antioxidants for carotene.

Bickoff, E. M. *J. Am. Oil Chemists Soc., 29*, 445-6 (1952).

A variety of compds. were evaluated as antioxidants for carotene in mineral oil soln. by an accelerated stability test. These included derivs. of aromatic amines, substituted dihydroquinolines, ureas, phenothiazine, azobenzene, and diphenylmethane. The most effective antioxidants were hydroxy- and amino-substituted diphenylamines, p-substituted phenylenediamines, and derivs. of *2, 2,* 4-trimethyl-1, 2-dihydroquinoline.

Cysteine and glutathione in orange juice.

Jansen, E. F., and Jang, R. *Archi Biochem. Biophysics, 40*, 358-63 (1952).

The major part of the sulfhydryl compds. of both Valencia and Navel orange juice was found to exist as cysteine and glutathione. The effect of these two sulfur derivs. on flavor was not shown.

Evaluation of the biological values of the proteins in fish meals by the nitrogen retention method.

Sure, B., and Easterling, L. *J. Nutrition, 8*, 401-05 (1952).

A study was made of the biol. values of various fish meals by the nitrogen retention method. All of the fish meals were found to have high biol. values. However, because of low digestibilities, the net utilization of the proteins in crab meal and in anchovies meal was lower.

Heat denatured gelatin.

Tice, L. F., and Moore, A. W. *J. Am. Pharm. Assoc., 41*, 631-3 (1952).

Gelatin, when subjected to prolonged heating at high temp. is denatured. Such heat-denatured gelatin is altered in its soly. characteristics but is still subject to enzymatic hydrolysis. The changes which take place in gelatin thus treated are described, and certain applications of the product are suggested.

The conversion of collagen to gelatin and their molecular structures.

Ames, W. M. *J. Sci. Food Agric., 3*, 454-63 (1952).

A systematic account is given of the conversion of collagen to gelatin. It is shown that collagen can be converted into two types of gelatin of differing nitrogen content. A study of heat degradation has made it possible to sep. the effects of heat and chem. treatment in the prepn. of one type. The results have been collated by means of diagrams of mol. structure which lead to useful deductions and suggestions for further investigation.

Making pectin from lemons.

Food Eng., 24, 134-7, November, 1952.

How peel is processed to yield rapid and slow-set products. Complete flow sheet is given.

Engineering quality pectins.

Joseph, G. H., and Havighorst, C. R. *Food Eng., 24*, 87-9, November, 1952.

Pectin processing steps are discussed in detail.

Regulations for the enforcement of the federal insecticide, fungicide, and rodenticide act.

Production and Marketing Administration. *Federal Register, 17*, 11626 (1952).

The sections on registration and shipments for exptl. use are amended. If an economic poison is to be tested for a use which is likely to result in a residue on or in food or feed, a permit for shipment or delivery will be issued only when: (1) The food or feed product will not be used for food or feed except for lab. or exptl. animals, or (2) Convincing evidence is submitted by the applicant that the proposed use will not result in an amt. of residue which would be hazardous to man or other animals.

Chlorophyll no deodorant.

Science News Letter, 62, 36 (1952). The supposed deodorizing effect of chlorophyll and other properties are refuted by Prof. A. H. Corwin, head of the Dept. of Chemistry in John's Hopkins University.

Production of expanded rice products.

Roberts, R. L. Assignor to the U. S. A. 2,616,808, November 4, 1952.

Abstracts

A process for prepg. ready to eat rice products which comprises providing discrete grains of parboiled rice, the grains being in an at least partially cooked state having a dense, hard structure and a moisture content from about 8% to about 14%, subjecting the grains to a heat treatment at a temp. from about 170° C. to about 250° C. whereby the grains are expanded to form porous crisp grains having the same shape as the original grains, the expansion causing the formation of a multitude of small spherical voids uniformly dispersed throughout the interior of the kernels, the porous grains having a bulk volume from about 2 to about 6 times that of the starting grains.

Plastic shortenings and process of producing same.

BAUR, F. J., AND LANGE, W. Assignors to the Procter & Gamble Co. 2,614,937, October 21, 1952.

A process of manufg. plastic shortenings contg. an amt. of hardstock consisting of triglycerides of high mol. wt. satd. fatty acids materially in excess of the amt. of such triglycerides obtainable by random rearrangement of all the glycerides of the shortenings, which comprises prepg. a mixt. comprising essentially triglycerides which contain in their mol. structure both acetyl groups and acyl groups of high mol. fatty acids, the mixt. being free of non-glyceride esters whose volatility is not greater than that of diacetyl triglycerides, removing from the mixt. materials more volatile than diacetyl triglycerides of the fatty acids, the combined fatty acids of the resultant mixt. being at least ⅓ acetic on a molar basis, chilling substantially triacetin-free triglycerides comprising as a major component the thus purified product, and comprising a minor amt. of the hardstock as a firming agent and forming same into a plastic mass.

PACKAGING

Dessicants in protective packaging.

GRIEPENKERL, E. C. *Food in Canada, 12*, 16, November, 1952.

Dessicant will absorb moisture present when article is packed and will absorb moisture entering the package.

Evaluation of heat-seal adhesives.

WITTCOFF, H., AND PEERMAN, D. *Modern Packaging, 26*, 135-40, November, 1952.

The various types of heat seal (thermoplastic) adhesives are described and methods of evaluation are discussed. The prepn. of the film for evaluation, detn. of sealing temp. and sealing range, formation of bonds between various surfaces, and detn. of bond stability are discussed. An app. for the detn. of sealing range is described.

PHYSICAL RESEARCH

An improved apparatus for the study of foams.

WALLING, C., RUFF, E. E., AND THORNTON, J. L. *J. Phys. Chem., 56*, 989-93 (1952).

An improved app. has been designed for the study of phys. properties of bulk foams, foam drainage, foam compn., viscosity and rate of bubble collapse. Advantages over previous designs are discussed and results with various surfactants are given.

A vibration pickup amplifier.

GARNER, L. E. *Radio Television News, 49*, 48-9, January, 1953.

Construction details on a useful gadget designed to permit the analysis of various types of mech. vibration.

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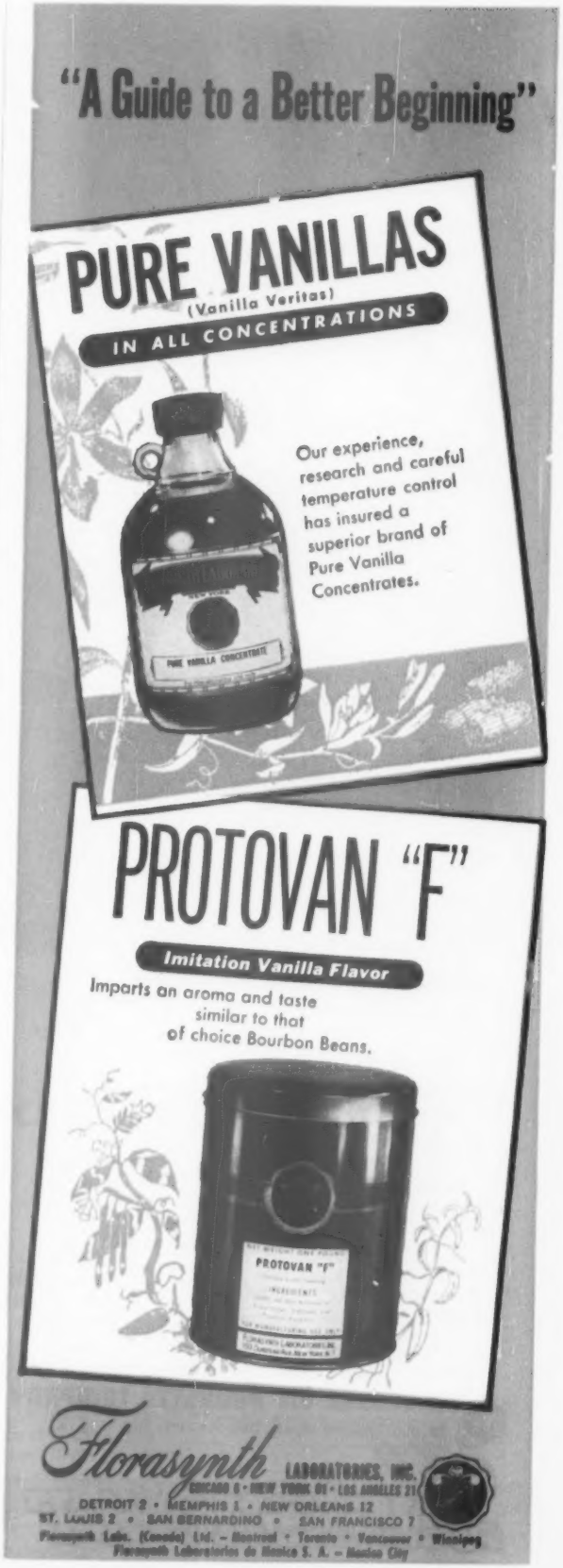
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THIRD SURVEY OF FOOD AND NUTRITION RESEARCH IN THE UNITED STATES

About 3000 research projects have been listed to date in the third survey of food and nutrition research being conducted by the Food and Nutrition Board of the National Research Council. The cooperation of academic, governmental, and industrial research organizations in supplying this information has been excellent. July 1 has been set as the deadline for receipt of information. In the forthcoming publication, the project titles will be arranged in eleven sections: Nutritional Requirements, Digestion and Metabolism, Nutritional Deficiencies, Nutrition Surveys, Methodology Pertaining to Nutrients, Enzyme and Hormone Chemistry, Food Composition, Factors Affecting Nutritive Value, Microbiology, Food Acceptance, Nutrition Education. A register of workers in this field, a list of organizations conducting and/or supporting the research, and a subject index will be included. A new feature will be the inclusion of suggested food and nutrition research projects in areas where further work is indicated.

FUTURE DATES FOR FOOD TECHNOLOGISTS

1953	
April 6-10	American Society of Biological Chemists, Chicago, Illinois
April 6-10	American Institute of Nutrition, Chicago, Illinois
April 13-15	National Fisheries Institute, Washington, D. C.
April 20-22	American Management Association, National Packaging Exposition, Chicago, Illinois
April 20-22	National Frozen Food Industries Exposition, New York, N. Y.
April 21	Association of Consulting Chemists and Chemical Engineers. Symposium. New York City, New York
April 21-22	American Dry Milk Institute. Annual Meeting. Chicago, Illinois
May 3-7	American Society of Brewing Chemists. Annual Meeting. Cincinnati, Ohio
May 4-6	Forty-fourth Annual Meeting of the American Oil Chemists' Society, New Orleans, La.
May 11-12	National Cottonseed Products Association. Annual Meeting. Los Angeles, California
May 12-13	American Institute of Chemists. Annual Meeting. Philadelphia, Pa.
May 20-22	International Council of Industrial Editors. Twelfth annual convention. Houston, Texas
May 25-27	Technical Association of the Pulp and Paper Industry. Fourth Conference on Coatings. Cincinnati, Ohio
May 25-28	American Association of Cereal Chemists. Thirty-eighth Annual Meeting. Buffalo, New York
May 27-29	American Society for Quality Control. Annual Convention. Philadelphia, Pa.
June 10-12	Research and Development Associates, Food and Container Institute, Inc. Sixth Annual Meeting. Washington, D. C.
June 14-18	National Confectioners' Association. Seventieth Annual Convention. New York, N. Y.
June 21-25	**Thirteenth Annual Meeting of the Institute of Food Technologists, Boston, Massachusetts**
June 22-24	American Dairy Science Association. Annual Meeting. Madison, Wisconsin
June 22-30	Eleventh Conference on the Standardization of Methods for Sugar Analysis. Paris, France
June 25-27	Twenty-seventh National Colloid Symposium, Iowa State College, Ames, Iowa

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

"Mother's asleep now, son," Dad told him. "She'll be asleep a long, long time. It's kind of like going away. We'll have to learn to get along without her, Johnnie."

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Advertisers' Index

	PAGE
American Cancer Society	39
American Optical Co.	23
Aseptic Thermo Indicator Co.	41
Brewers Yeast Council, Inc.	40
Continental Can Co.	6-7
Diamond Crystal Salt Co.	30
Distillation Products Industries	25
Dodge & Olcott, Inc.	17
Felton Chemical Co.	19
Firmenich, Inc.	9
Florasynth Laboratories, Inc.	37
Food Development Laboratory	42
Food Machinery & Chemical Corp.	13
Food Research Laboratories, Inc.	42
Food Technology, Inc.	36
Fritzsche Bros., Inc.	42
The Griffith Laboratories, Inc.	31
Hoffmann-LaRoche, Inc.	24
Huron Milling Co.	26
International Minerals & Chemical Corp.	36
Klenzade Products, Inc.	34
H. Kohnstamm & Co., Inc.	11
LaWall & Harrisson	41
Magnus, Mabee & Reynard, Inc.	4
Merck & Co., Inc.	35
Minneapolis-Honeywell Regulator Co.	32-33
Norda Essential Oil & Chemical Co., Inc.	4th cover
The Pfaudler Co.	2nd cover
Chas. Pfizer & Co., Inc.	29
Schwarz Laboratories, Inc.	42
Seaplant Chemical Corp.	20
Foster D. Snell, Inc.	42
A. E. Staley Mfg. Co.	3
Wm. J. Stange Co., Inc.	1-2
Sterwin Chemicals, Inc.	21
Sugar Information, Inc.	3rd cover
Universal Oil Products Co.	38
U. S. Stoneware, Inc.	27
van Ameringen-Haebler, Inc.	15
Wallace & Tiernan, Inc.	40
Wisconsin Alumni Research Foundation	40

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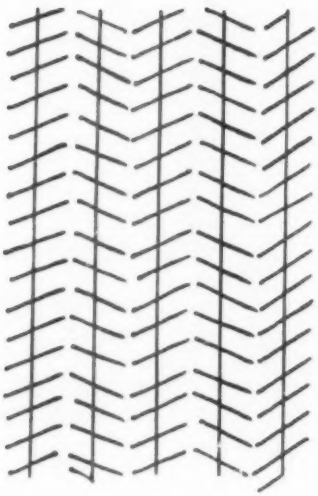

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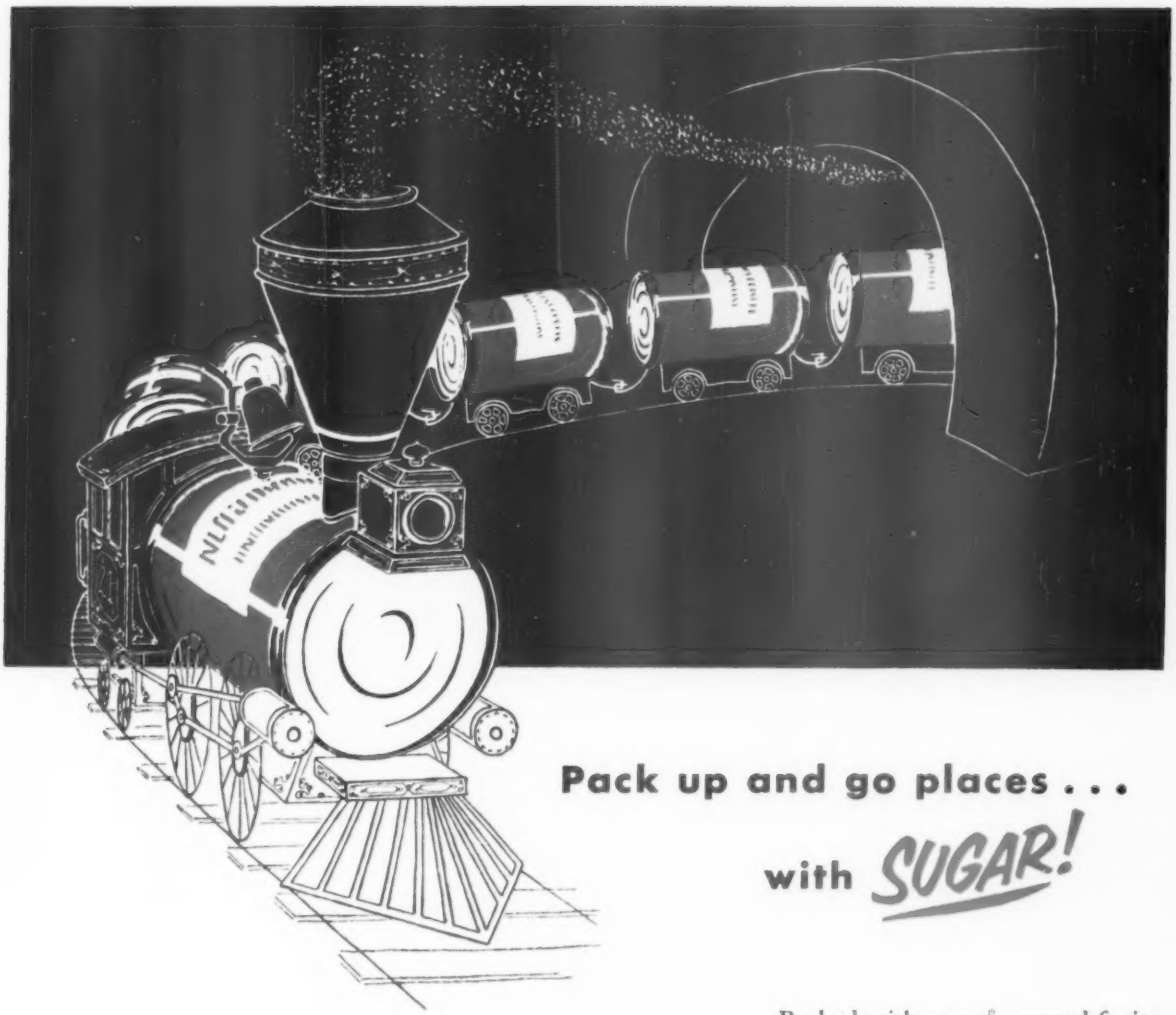

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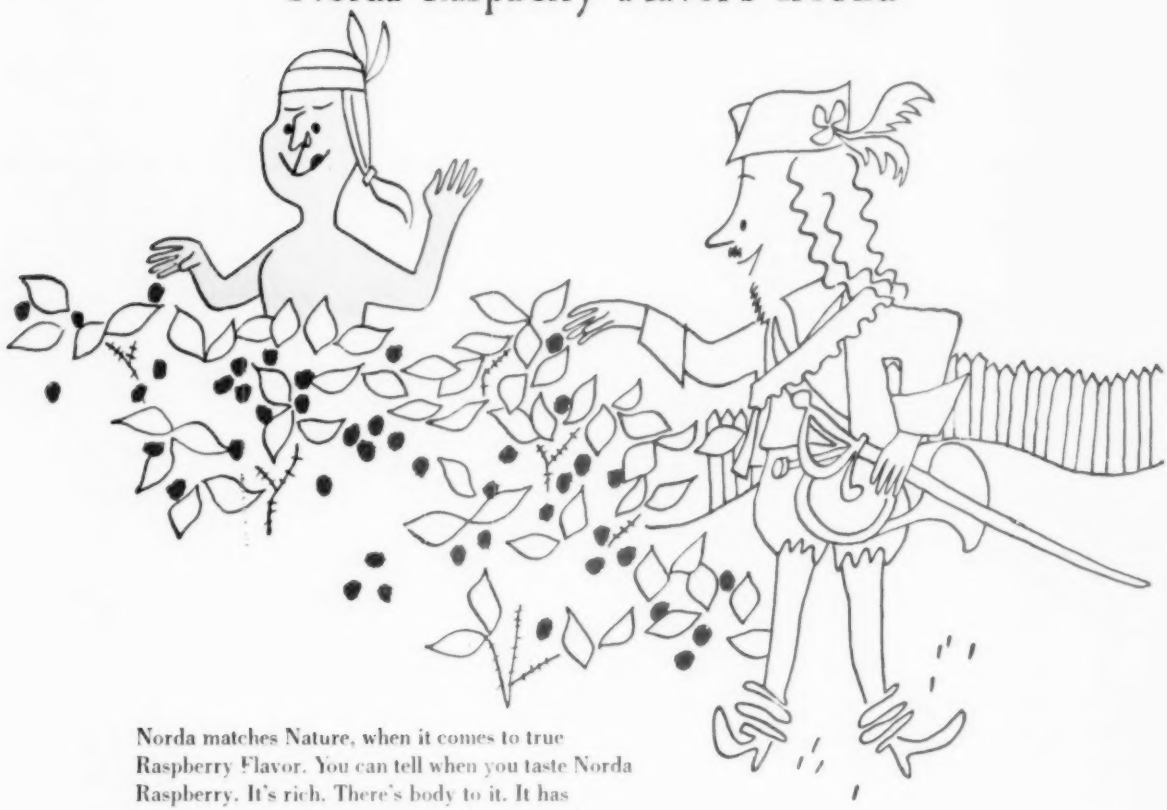

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